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WEST INDIAN BULLETIN

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(CONTINUED.)

COTTON.

THE RESULTS OF THE CULTIVATION OF COTTON IN ST. VINCENT.

BY W. N. SANDS,

Agricultural Superintendent, St. Vincent.

At the West Indian Agricultural Conference, held in 1908, the results of the cultivation of cotton at St. Vincent were given. In order that the story of the progress made since may be brought up to date, this paper is now submitted.

Satisfactory progress continued to be made, with the result that the cotton industry is now the premier industry of the Colony. It is of interest to record that the value of the exports of Sea Island cotton and seed alone last season was at the rate of over £1 per head of the population of the Colony, which on April 2, 1911, stood at 41,877.

Unfortunately but little progress could be reported with the short-stapled Marie Galante cotton industry of the Southern Grenadines. The Government has, however, lately acquired Union Island, the largest of these islands, and sold out the land to the peasantry in the form of small holdings. During the present season, as a result of this action, the exports of this cotton and seed are likely to show a substantial increase.

Exports of Cotton and Value of Crop.

The following table, compiled from Customs statistics for the past eight years, shows the weight and value of the exports of cotton for that period :—

Year.	Sea Island cotton.	Estimated value.	Total exports of Sea Island and Marie Galante.	Total estimated value.
	lb.	£	lb.	£
1903-4	Not known	...	43,392	794
1904-5	77,814	3,890	126,178	4,494
1905-6	121,174	6,059	138,150	7,674
1906-7	225,632	16,922	263,036	18,169
1907-8	388,833	29,162	427,819	30,787
1908-9	432,091	28,971	459,303	29,878
1909-10	372,057	25,987	394,667	26,775
1910-11	515,237	40,790	540,339	41,836
Total ...	2,132,838	151,781	2,392,884	160,407

The above figures refer to the exports during each financial year, April 1 to March 31, and do not coincide with the crop year, October 1 to September 30; still the record is of value in that it shows the progress of the industry.

It will be seen that the exports of Sea Island and Marie Galante lint in 1903-4 were 43,392 lb. valued at £794, whereas last year the exports totalled 540,339 lb. valued at £41,836, and of this amount Sea Island cotton was represented by 515,237 lb. of an estimated value of £40,790. It is further shown that during the past seven years the total value of the exports of this cotton amounted to no less than £151,781.

Last season a larger acreage was planted than in any previous year, and the yield per acre was above the average. The prices for lint and seed during the earlier part of the season were good, but a decline took place towards the end of the season. The prices obtained for white Sea Island lint ranged

from 18*d.* per lb., the lowest price for average qualities, to 25*d.* per lb. for the extra superfine or fancy lots.

The following is an estimate of the value of the 1910-11 crop based on the actual yield and prices realized :—

561,526 lb.	Sea Island cotton	at 18*d.* per lb.	£42,114
752 tons	,, cotton seed	,, £5 per ton	3,760
26,748 lb.	Marie Galante cotton	,, 9*d.* per lb.	1,003
35 tons	,, cotton seed	,, £5 per ton	175
	Total estimated value ...	...	£47,052

This estimate shows at a glance what a valuable asset the cotton industry is to St. Vincent.

Acreage Planted and Yield Per Acre.

Under the Agricultural Products Protection Ordinance 1909, all cotton growers are required to send in returns of the acreage planted on or before September 30 in each year. It is now easier to obtain reliable figures for statistical purposes.

Last season the total acreage returned was 4,680 acres, made up of 3,587 acres of Sea Island cotton, and 1,093 acres of Marie Galante.

Information as to the amounts of cotton ginned are obtained each year from the different ginneries as soon as ginning is completed.

The table given below shows the acreage planted in Sea Island cotton in each crop year of the past six years, together with the yield of lint and the average yield per acre.

Crop year.	Area planted. Acres.	Weight of lint. lb.	Yield of lint per acre. lb.
1905-6	790	137,460	174
1906-7	1,533	268,275	175
1907-8	3,200	432,000	135
1908-9	3,000	372,000	124
1909-10	2,528	356,139	141
1910-11	3,587	561,526	156
		Average for six years	150

The average yield per acre for the past six years is 150 lb. Of much interest in connexion with last season's results is the fact that the heavier yield of 156 lb. per acre was obtained from 3,587 acres, or 1,059 acres in excess of the 1909-10 acreage, when the yield was 141 lb. It will be seen that in the years 1907-8 and 1908-9 acreages of 3,000 and 3,200 respectively

showed considerably decreased yields per acre as compared with the yields obtained in the two previous years from much smaller areas. Although the 1910-11 season was a fairly favourable one in most districts, still improved cultural methods, such as are constantly advocated by the Imperial Department, undoubtedly had a beneficial effect. The low average yield per acre was due to the heavy rainfall of many districts favouring the growth of bacterial and fungus diseases. It is estimated that many estates each season lose 25 per cent. of their crops owing to disease. In a season when the rainfall is above the average, such as at present, quite 75 per cent. has been lost in some places from this cause.

The area returned as being under Marie Galante cotton last season in the Southern Grenadines was 1,093 acres, but it was thought that this total was much in excess of the actual area under cultivation; in fact, it is doubtful if 750 acres were actually cultivated.

The crop figures, therefore, for this cotton cannot be regarded as very trustworthy, except those for actual outturn of lint. This amounted to 26,748 ℔, or just over 72 bales of 360 ℔ each. If the acreage returned was reliable then the yield per acre was 24 ℔. only—a very unremunerative return for a cotton which sold at from 9*d.* to 10*d.* per ℔.

The lint percentage of Marie Galante seed-cotton is below 24. This is such a low percentage for this class of cotton, combined with a low yield per acre, that efforts have recently been made to induce the people to plant heavier-yielding types, and for this purpose selected seed for planting was obtained from the Commissioner of the neighbouring island of Carriacou, who has selected a cotton which produces seed-cotton yielding 31 per cent. of lint. Seed of the fine Egyptian cotton known as Sakellarides has also been planted in small experiment plots in each islet. This seed was obtained by the Imperial Commissioner of Agriculture, and distributed by the Agricultural Department.

Ginneries and Ginning Results.

The Government Central Cotton Ginnery, with eight gins, is the largest in the Colony, and has been managed by the Agricultural Department since it was erected in 1904. The Kingstown Ginnery is the second largest, with five gins. There are two other ginneries on estates, where two and one gins respectively are worked.

It is possible that one or two more estates will erect gins; if so, this will lead to a certain amount of decentralization, which is to be regretted for the reason that the close expert supervision given to the work in the large ginneries will not be available in the small ones, and there may be therefore some danger of the quality of the lint being lowered.

The following is a summary of last season's ginning results at the Central Cotton Ginnery, where about one-half of the Colony's output of Sea Island cotton and six-sevenths of the Marie Galante are dealt with:—

Kind.	Weight of seed-cotton.	Weight of lint obtained.	Percentage of lint to seed-cotton.	Percentage of stained lint.
	lb.	lb.		
From estates				
Sea Island (white)	790,928	195,705	24·7	
(stained)	109,799	27,779	25 3	14·1
Purchased from small growers				
Sea Island (white)	177,040	46,963	26·5	
(stained)	26,136	6,853	26·3	14·5
Purchased at Union Island, Canouan and Mayreau				
Marie Galante (white)	91,095	21,912	24	
(stained)	1,798	472	26 5	2·1

The chief point which calls for comment is a low percentage of lint in the seed-cotton from estates. This averaged 24·7 per cent. for white cotton as compared with 26·5 per cent. for first grade cotton produced by small growers. This was due to the fact that several estates grew extra superfine cotton. Although this cotton gives, on an average, a yield of seed-cotton quite equal to the Rivers type, the lint percentage is only from 22 to 24 against 26·5. It is calculated that the extra fine cotton has to sell for at least $2\frac{1}{2}d.$ per lb. more than the ordinary Rivers type to make it as remunerative to grow. During the past season, however, the prices have ranged from 5*d.* to 6*d.* per lb. more. In some seasons it is most difficult to sell this fancy cotton, as the demand for it is so very limited. This is a factor which has to be taken seriously into consideration, and one that is likely to retard any large extension of planting of this particular type.

In 1909 an Ordinance was passed to regulate the purchase of cotton, in order to suppress cotton stealing. Under this Ordinance all lots of seed-cotton less than 100 lb. in weight have to be sold to the Government Central Ginnery. Under the regulations made, the seed-cotton presented for sale is purchased on a profit-sharing basis. The method now adopted is to pay one-quarter of the estimated value of the lint per lb. less 5 c. for ginning and shipping charges and export duty. At the

present time the highest price paid for seed-cotton is 6½ c. per lb. and is arrived at as follows: estimated market value of 1st grade lint, 30 c. per lb.; less 5c. for ginning, etc., 25 cents; one-quarter of 25 gives 6¼c. per lb., for seed cotton.

At the end of the crop, and as soon as all account sales for lint and seed have been received, a bonus equal to three-quarters of the net profits is distributed. This is calculated on a percentage basis on the amount paid for seed-cotton and not on the weight of seed-cotton sold.

Last season, a bonus of 25 per cent. or 5*s*. for every £1 worth of seed-cotton was distributed. As 7c. per lb. was paid on account, this meant that the grower received altogether 8¾c. per lb. for his 1st grade white lint.

The weights of seed-cotton purchased last season under the profit-sharing scheme were 203,176 lb. of Sea Island and 92,893 lb. of Marie Galante, and the sum paid on account to small growers amounted to £3,352, which with the amount of bonus —£838—made the total payments £4,190. Two hundred and twelve bales of lint were shipped as against 67 bales the previous season. This season's indications point to the fact that a much greater volume of business will be transacted.

Although the small grower has to sell lots of seed-cotton of less than 100 lb., yet this does not preclude the sale to the ginnery of larger lots. The largest quantity, however, which can be purchased from any one grower without the permission of the Administrator is 4,000 lb.

Cotton-growing by the Peasantry.

A noteworthy feature of the past two years has been the extension of cotton-growing by the peasantry. The inauguration by the Government of the profit-sharing scheme mentioned above, and the favourable prices paid by licensed dealers, undoubtedly stimulated the planting of cotton by these people. The figures of the acreage planted in 1909-10 are not available, but in 1910-11 there were 542 small growers of Sea Island cotton and the total area they had under cultivation was 916 acres. It is estimated that a larger acreage has been planted this season (1911-12).

The greater proportion of the seed sown by the peasantry was supplied by the Agricultural Department. The practice adopted is to reserve seed from the best lots of cotton purchased at the time of ginning, and then, provided the field reports made by the Agricultural Instructor and Cotton Inspector are satisfactory, the seed is tested and then selected and disinfected. The price at which this seed was sold was 5c. per lb. The advantages derived by the small growers in being able so readily to obtain reliable seed of good germination at practically cost price cannot be over-estimated.

The seed work, which entailed the handling of over 5 tons of seed in small lots, required very careful supervision, but it was undoubtedly work of the greatest importance to the industry in that it maintained the quality of the small growers' produce.

The Officers of the Agricultural Department kept in close touch with the people, and constant advice and assistance were given them in connexion with the different cultural operations.

Legislation.

In order to protect and safeguard the cotton industry in respect of pests and diseases, an Ordinance was passed in 1910 called the Cotton Diseases Prevention Ordinance. Under its provisions all growers are required to destroy completely by fire, on or before April 30 in each year, all cotton bushes that were planted or growing during the previous cotton season, which for the purpose of the Ordinance was, in St. Vincent, May 1 to April 30. This applies to all cotton of whatever kind grown. In the case of the Northern Grenadines, however, the plants have to be destroyed on or before March 31, in each year, as planting is as a rule started earlier than in St. Vincent. The Ordinance also provides for the appointment of Officers to see that its provisions are carried out. Should a grower neglect to destroy his old bushes at the proper time he may be fined or imprisoned, and further the officers can enter upon his land with the necessary labourers to pull up and burn the bushes and then recover the cost of the work in the Small Debts Court. This is probably the first Ordinance to make it compulsory for growers to destroy both wild and cultivated types of cotton, at the end of a crop, that has been enacted in the cotton-growing islands of the West Indies. With a number of pests and diseases which could be carried over from season to season by means of the old bushes, the result of the passing of this Ordinance is likely to be of much benefit to the local industry.

The Ordinance does not apply to the Southern Grenadines where practically only the perennial Marie Galante cotton is grown.

Methods of Cultivation, Labour, etc.

Steady progress has been made with implemental tillage, introduced by the Imperial Department of Agriculture in 1910, and a considerable extension of this form of tillage is to be looked for in the near future. During the present season (1911-12) seven estates growing cotton have used two or more modern implements, and orders for further sets of implements with modifications to suit local conditions have been placed by cotton growers.

A large number of male labourers having left the Colony to work in the Panama Canal Zone and Brazil, estates have found it rather difficult to obtain sufficient labour to cultivate their cotton lands thoroughly. This shortage of labour is likely to be more severely felt in the near future; still many estates ought to be able partly to make up for this labour deficiency by adopting mechanical tillage for lands suitable for this method of cultivation.

On most estates the value of pen and other organic manures for cotton is now recognized, and the systematic

preparation of these manures, more particularly pen manure, is carried out on extended lines.

A fairly large area of Bengal beans for green dressing purposes is grown. This bean grows particularly well in the island, and no serious insect attack has so far been observed. Other green dressing plants used are pigeon peas and cowpeas.

Selection of Seed for Planting.

In the island of St. Vincent, where only Sea Island cotton is grown, reliance on seed for planting has been placed by estates on the produce of the best crop lots: that is the seed from particular fields with plants of good field and lint characters is reserved and then selected. The practice adopted in preparing the seed is as follows. The seed is first of all tested, and only that giving a germination of not less than 85 per cent. is retained. It is then delinted, to facilitate the work of selection, and spread out on tables covered with white cloth. Women who have been specially trained in the work select the type showing the characters desired: that is a heavy, sound black seed with a green tuft of fuzz at one or both ends. Seed that does not come up to this standard is rejected. The selected seed as a rule represents from 60 to 75 per cent. of the whole. Since the season of 1904-5 this practice has persistently been followed by the Agricultural Department and planters. As is mentioned above, no other type but Sea Island cotton has been grown, and that chiefly the Rivers' variety introduced in 1904 from the Sea Islands of South Carolina. As a result of seven years' selection on those lines, the quality of the local produce has been maintained, and the type fairly well adjusted to local conditions. The cotton is so highly esteemed by spinners that planters have been advised not to make any change unless, of course, the cultivation proves unremunerative.

Plant Selection for Seed.

Perhaps the most important line of work is in the direction of experiments to select types showing resistance to certain bacterial and fungus diseases. This work was started five years ago on several estates and continued for one and, in some cases, two years, but the value of it was apparently not fully recognized by planters at that time, or they found themselves unable to give the necessary close attention to the selected plants and the picking of the seed-cotton. The work, therefore, was not continued. However, during the 1909-10 season, plant selection was recommenced on two estates. During the 1910-11 season this work was continued on one additional estate, and also at the Botanic Station and Agricultural School. Owing to the difficulty still found by estates in giving close attention to the experiments, the seed from the selected plants was grown at the Agricultural School. The rainfall is very heavy, so that conditions are favourable for continued tests for resistance to disease.

The experiments of the present season, although not concluded at the time of writing (January 1912), have shown some

very promising results notwithstanding that the rainfall has been the heaviest recorded since the establishment of the local Sea Island cotton industry.

Besides this line of work, experiments are being made at the Agricultural School in raising hybrids of certain native and imported types and the local Sea Island in the endeavour to obtain a fixed strain of robust growth and a heavy yield of cotton of good quality. This is a work that requiries careful supervision over a long period, and one that has to be carried on in isolated plots. It is not work that it is advisable for estates growing good Sea Island cotton to undertake, except under very special circumstances.

Pests and Diseases.

No attack of the cotton worm (*Alabama argillacea*) has been recorded during the past four years. The chief natural enemy, the Jack Spaniard (*Polistes annularis*), is now preserved on nearly all estates. On some estate buildings hundreds of nests are to be seen. Although the wasp appeared to prefer the shelter of buildings, it also built its nest in trees and hedges and other places and is well distributed throughout the island.

The local cotton stainer (*Dysdercus delauneyi*) is a pest which is always found in fairly large numbers in each season, towards the end of the crop. Although no definite experiments have been made to ascertain the actual amount of damage done by it, it was observed last season on one estate that seed from a special plot badly attacked by the cotton stainer gave a germination of only 20 per cent.; under ordinary circumstances, the seed should have given a germination of at least 90 per cent. The seed-cotton was thoroughly well prepared and the bolls from which it was obtained were healthy. There is no doubt that the cotton stainer is a pest against which measures will have to be taken to keep it in check. It is able to carry on its existence in the close season by feeding on the fruits of certain trees and plants, among these being the silk cotton (*Eriodendron anfractuosum*), John Bull or mahoe (*Thespesia populnea*), Tobago bread nut (*Pachira spruceana*) and Ochro (*Hibiscus esculentus*). It also attacks the flowers of the mango, and a severe attack on any tree usually leads to a small crop. Besides, it was seen on trees badly affected with scale insects, apparently feeding on the honey dew secreted.

The usual methods of trapping recommended have not been adopted on account of the lateness of the attack and the labour involved; still, should the pest increase and attack the cotton at an earlier stage than usual, trapping will have to be resorted to, in order to prevent serious damage.

Some estates have destroyed the native trees near their fields, which attract the stainer, in order to reduce its food supply, and of course the destruction by fire of all the cotton bushes at the end of each crop has a controlling effect.

The leaf-blister mite (*Eriophyes gossypii*) attacked the cotton plants towards the end of each season, in all districts. Now that the complete destruction of the stalks at the end of

a crop is made compulsory, this pest will be kept in check and enable second pickings to be obtained from well cultivated fields.

Black scale (*Saissetia nigra*) is a pest which has spread considerably during the past three years and has done a large amount of damage. It now occurs on several estates in the Windward district where previous attacks had not been observed. The chief natural enemies of other islands, namely the small parasite (*Zalophothrix mirum*) and the fungus (*Cephalosporium lecanii*) are present, but have a very limited controlling effect in the growing season. It has been suggested that the practice of burning the cotton stalks at the end of a crop might prevent the parasites from multiplying, but as there are so many native trees and plants on which the scale insect thrives, these should allow the natural enemies to continue their existence if local conditions are favourable. For some reason favourable conditions do not appear to exist in cotton fields in average seasons, so that reliance has, at any rate for the present, to be placed on the destruction of the old cotton stalks and the native trees and plants which carry over the black scale from season to season. Importations of parasitized scales have been made from Barbados, with the hope of establishing centres from which well-parasitized material will be available for distribution to estates.

A small bronze leaf-eating beetle has proved a troublesome pest in the earlier stages of the crop in some districts. Cases occurred where whole fields had to be resown. Anything that stimulated rapid growth helped the plants to throw off an attack. A light dusting of Paris green was also found effective in one or two cases.

The angular leaf spot, black arm, or bacterial boll disease, attributed to *Bacterium malvacearum*, was the most serious disease affecting cotton in St. Vincent. It attacks the plants in all stages of development, and its growth is favoured by the heavy rainfall. The extent of the damage done in each season chiefly by this particular disease, and the efforts which were being made to breed types resistant to it, have already been described.

The cotton mildew fungus is as a rule a late blight, and in average seasons is not responsible for much damage, but during the present season when the rainfall has been above the average it has done a considerable amount of harm to leaves and bolls.

Another fungus, anthracnose (*Colletotrichum gossypii*) has also done some damage to the bolls this season.

These bacterial and fungus diseases are difficult to control, but the hope is expressed that the experiments in progress will show that it is possible to breed types of cotton showing a certain amount of resistance to them. In regard to the chief disease, angular spot, plants already fairly immune to it have been selected. These have stood the severe test of this season extremely well, and their behaviour under estate conditions next season will be watched with much interest.

THE COTTON INDUSTRY IN THE LEEWARD ISLANDS.

BY H. A. TEMPANY, B.Sc.,

Superintendent of Agriculture for the Leeward Islands.

In the *West Indian Bulletin*, Vol. XII, p. 7, an account is given of the progress of the cotton industry in the Leeward Islands up to the end of April 1911. The following additional notes have been compiled with the co-operation of the Agricultural Officers in the different Presidencies and bring the account up to date, that is up to the time of the Agricultural Conference in January 1912.

Antigua.

In Antigua, the amount of cotton produced for the crop of 1910-11 amounted to 96,992 ℔. of lint—an average yield of 173 ℔. per acre.

For the current season 1911-12, 517 acres have been planted in Antigua and 130 in Barbuda, making a total area of 647 acres under the crop at the present time.

Considerable difficulty was once again experienced in establishing the crop, owing to drought; had it not been for this, it is probable that a larger area would have been planted. At the present time the crop, on the whole, presents a fairly satisfactory appearance, though a considerable amount of trouble has been experienced owing to insect pests.

St. Kitts-Nevis.

In the Presidency of St. Kitts-Nevis, the total exports of lint for the crop of 1910-11 were as follows :—

	℔.
St. Kitts	329,322
Nevis	343,395
Anguilla	148,595
Total ...	821,312

The total area from which this was produced was approximately 3,800 acres, and the total return of lint per acre for the Presidency amounted to 216 ℔.

In St. Kitts the return per acre is about equal to that of the previous season, while in the case of Nevis the yield is the largest recorded since the inception of the industry.

The large return in Nevis constitutes a striking feature. It is all the more remarkable in view of the fact that out of the total area of 1,300 acres grown 540 were under cultivation by peasants. The yields from the area cultivated in this way compared favourably with, and in some cases exceeded, those obtained on estates. The care and attention given by the peasants to

their cotton were worthy of much praise. That it has been brought about is attributable to the fact that provision has been made through the Agricultural Department for the obtaining of selected and disinfected seed of good strain suited to local requirements, at 1*d.* per lb., and to the unremitting supervision and advice given by the Agricultural Instructor.

In Anguilla, also, a fairly satisfactory yield was recorded, though considerably less than was the case in the other islands of the Presidency. Here cotton-growing is almost entirely carried on by the peasants. Mr. Carter Rey, the owner of the ginnery in the island, has contributed greatly to the successful establishment of the industry. In this he is assisted by annual loans from the Local Government and the British Cotton Growing Association, which enable him to advance small sums to peasant growers to enable them to carry out their cultivation.

For the present season (1911-12) the following areas have been planted under the crop :—

St. Kitts	1,650 acres	
Nevis	2,000 acres	
Anguilla	800 acres	(estimated)

In all three islands unfavourable weather interfered with the planting of the crop. St. Kitts suffered least in this respect, however, and the prospect appears to be for a fair return, on the whole. In Nevis, much difficulty was experienced in establishing the crop, which is late ; severe attacks of cotton worm have also been responsible for considerable damage. On this account, the outlook for the present season is distinctly poor.

In Anguilla, the young crop has suffered very much from the attack of a small beetle which cuts down the young plants. At the present time the crop is below the average, and there appears to be prospect of a small return.

Montserrat.

In Montserrat, the season 1911-12 up to the time of writing may be said to have been favourable in the main.

The earlier months of the growing season, June and July, were seasonable for the establishment of cotton, but August was exceptionally dry and in consequence the young crop suffered severely in many localities. The recurrence of favourable weather in September, however, sufficed to save the situation although in consequence of the check to growth experienced ; the crop in certain areas especially on the windward coast is late. On the whole, the prospect is for a satisfactory return.

The total area planted is estimated to amount to approximately 2,500 acres—a considerable increase over the previous season ; up to the time of writing (November 1911) the exports of cotton for the crop have exceeded 100,000 lb. of lint.

Attacks of insect pests of all descriptions have been severely felt throughout the season, but as a result of watchful and energetic supervision, no great amount of damage has resulted. Cotton stainers (*Dysdercus andreae*) have been encountered in large quantities in certain districts, while the flower-bud maggot

(*Contarinia gossypii*) has appeared extensively on the northern windward coast estates during the month of November. Owing to early planting, however, a satisfactory first picking has on a previous occasion already become developed, and the pest at the present does not constitute a factor of great importance in consequence.

Generally the outlook for the industry is promising; as a result of good returns, considerable increases have taken place in the area under the crop planted by peasants. Large areas of land have been reintroduced into cultivation which have been for many years previously in bush, and regular and remunerative employment found for a considerable section of the labouring community which previous to the introduction of cotton, had existed in a condition of the most abject poverty.

Further extensions of the area under the crop are at the present time probably limited by the available labour-supply.

For the crop of 1910-11, 50,337 lb. of lint were reaped and exported. This is a very satisfactory increase over the return of the previous season, though it still falls somewhat short of the yield in 1908-9.

Extremely unfavourable weather has greatly handicapped the industry during the present year (1911); the severe drought experienced from May to October stood in the way of all planting operations and administered a check to the crop from which the incidence of favourable weather late in the season has now induced a partial recovery.

THE COTTON INDUSTRY IN BARBADOS

BY J. R. BOVELL, I.S.O., F.C.S., F.L.S.,
Superintendent of Agriculture, Barbados.

As will be seen from the following table, the yield of the cotton lint in Barbados which was excellent at first, has gradually decreased, until during the last few years, the yield is practically only half what it was when the industry was first resuscitated.

Year.	Average yield of lint per acre, lb.	Year.	Average yield of lint per acre, lb.
1902-3	338	1907-8	137
1903-4	235	1908-9	145
1904-5	170	1909-10	156
1905-6	240	1910-11	153
1906-7	170		

When the decreased yields first occurred, experiments were started with the object of trying to increase the quantity and if possible the quality of the lint obtained. These experiments were undertaken by Mr. Thomas Thornton, A.R.C.S., Travelling Inspector in connexion with the cotton industry under the Imperial Department of Agriculture for the West Indies, and were conducted by him until he left the island at the beginning of 1908. The method adopted by Mr. Thornton was, that of selecting seed for replanting from the healthiest and most vigorous plants, producing good lint, grown from seed obtained from the Sea Islands. From the time Mr. Thornton left the island these experiments have been carried on and greatly extended by the Local Department of Agriculture. At the present time the experiments are carried on in two series. In the first series a number of the best plants are selected and labelled and a number of flowers selected and bagged, to prevent cross-fertilization, and when the bolls open the cotton from those bearing the best lint is picked. During the growth of the marked plants, notes are made as to the immunity or otherwise of such plants to fungoid diseases and insect pests, and also as to the habit of the plant, etc. As soon as the plants cease bearing, the seed-cotton from each plant is weighed and the lint carefully examined as to the characters which go to make up lint of the best quality. To each of the various characters numbers are assigned and the seed from the plant that obtains the highest number of marks is reserved for planting on the experiment plots in the following year.

The experiments in the first of the series, of which there are twenty, are carried on with the co-operation of a number of planters on estates situated in the different parts of the cotton districts and on land rented from Waterford plantation by the Barbados Government.

On the land rented from Waterford plantation, in addition to the cotton hybrid experiments which will be mentioned later, a number of varieties obtained from various sources are being cultivated and compared with plots of the best Sea Island cotton obtained by selection from Stirling plantation. The seed from which this cotton was grown was originally imported from the Sea Islands by Sir Daniel Morris.

In addition to these experiments in which the seeds from the healthiest and most vigorous plants producing good cotton are used, a second series of experiments was started in 1908 on land rented from Waterford plantation. These latter experiments have for thier object the crossing of the best plants grown from selected Sea Island cottons with indigenous cotton plants and with plants obtained from healthy and vigorous varieties of Sea Island cotton found growing in fields in which most of the other plants were dead or dying from various causes, including black arm, mildew, drought, etc. In some instances the cotton obtained from these plants is either too short, or too coarse, or not strong enough, but producing a heavy yield, and it is hoped by crossing these plants with good Sea Island cotton plants to produce a plant not only healthy and vigorous, producing a heavy yield, but one that will also bear cotton of good quality. As soon as the plants commence

to flower, a certain number of them which are cone-shaped, from 4 to 6 feet high, compact in habit, with a strong central stalk having numerous lateral branches, short internodes and bolls at almost every node, are marked with a piece of red braid and a stake is placed against each selected plant, so that it can easily be seen from a distance and readily found. As the flowers are sufficiently matured, the upper part of the corolla and the anthers are removed before they open and the remainder of the flower bagged to prevent promiscuous cross-fertilization, and a numbered metal label attached. At the same time a number of other flowers, from which pollen is to be obtained, are aiso bagged so as to prevent foreign pollen being introduced. As soon as the stigmas of the emasculated flowers are receptive, which is generally on the following day, they are pollinated with pollen from the flowers that have been bagged for that purpose. Portions of two of the bracts are cut off so as to distinguish the boll later on and the bag replaced, and a metal label with a number attached to each flower stalk. In three or four days' time, as soon as the style dries, the bag is removed. Later on, as soon as the bolls mature, a wooden label with the number of the plant is attached to the central stalk and two bags having a duplicate label are kept for putting the cotton from that particular plant in : one a comparatively large bag and the other much smaller, which is kept inside the large bag. In the small bag is placed the cotton from the marked bolls while the remainder of the cotton is placed in the large bag. It will therefore be seen that it is practically certain that the seeds from the bolls so obtained are of known parentage. It is also, with ordinary care, practically impossible for any mistake to be made with regard to one lot of seed being mixed with any other seed. In addition to the new hybrids, several thousand bolls from the best plants of the previous year's hybrids are bagged before the flowers open and the bags allowed to remain until the flowers have dried. The bag is then removed and a portion of one bract of the flower is cut off and the boll labelled with a metal label. These labels, it may be mentioned, are of a larger size and the figures are larger than those on the other labels so that they can be readily distinguished from the labels on the bolls that have been cross-fertilized.

So far the results obtained with the hybrids of the second year are most interesting, and confirm the results obtained by Mr O. F. Cook of the Bureau of Plant Industry of the United States Department of Agriculture, who in his bulletin on Suppressed and Intensified Characters in Cotton Hybrids, so clearly expresses the results obtained in the cotton experiments of the Barbados Department of Agriculture, when describing what took place with his experiments that it may not be without interest if I here reproduce what he says on the subject.

'Hybrids produced from two different types of cotton show a wide range of diversity, wider than that of either of the parent stocks. Some of the characteristics of the parent stocks may reappear in the hybrids without any notable change. In other respects the hybrids may be intermediate between the

parents, or they may exceed both parents, or they may be more deficient than either parent. Finally hybrids often show characters which the parental types are not known to possess.

'These different kinds of characters of hybrids may be described somewhat more definitely as follows:—

'*Parental characters*, inside the normal range of variation of one of the parent group.

'*Interparental characters*, representing combinations of parental character or intermediate stages between the characters of the parent group.

'*Extraparental characters*, not within the parental groups or beween them. Of extraparental characters three kinds may be distinguished, as follows:—

(1) *Suppressed characters*, representing the deficiency of a parental character or its reduction below either of the parent groups.

(2) *Intensified characters*, attaining a higher expression than in either of the parent groups.

(3) *Primitive characters*, representing the return to expression of characters of remote ancestors no longer brought into expression in the parent groups.

'It is not to be supposed that distinct lines can always be drawn between these different kinds of characters for there are all gradations of expression. Suppressed and intensified characters connect with parental characters on one side and with primitive characters on the other side. We may look upon the suppression of a character as a return to the ancestral condition far back in the evolution of the species, before the character was developed. Intensification might also mean the return of a character to an earlier state when it had normally received a greater degree of expression. Thus the green colour of the fuzz of the seeds of hybrid cottons which was discussed in a previous report as a primitive character, might also be viewed as an example of intensification.'

As the numbers designating the cotton hybrids are likely to become numerous, it has been decided, instead of letting them retain their ordinary numbers, to distinguish them by placing the letters B H, meaning Barbados Hybrid, before the last two digits of the year in which they were obtained, and then the number of the hybrid for that year. At the same time there will be entered in the report of the year in which these hybrids were obtained, their parentage, in order that persons interested can always refer to the reports of previous years for any information they may require with regard to any special variety. The parentage will at the same time be recorded in the register of these hybrids.

The following table contains a list of the hybrids first obtained, the names of their parents, the number of plants in the plot in 1910, the number of plants like the male parent, the number like the female parent and the number which varied so considerably that they resembled neither parent. The name of the female parent is mentioned first.

Names of Parents.	No. in plot.	No. like male parent.	No. like female parent.	No. which resembled neither the male nor female parent.
H. 0916 Grant × Stirling S. 11..	147	53	81	13
H. 0944 Stirling S. 11 × Grant ..	115	64	42	9
H. 0944 Stirling S. 11 × Grant ..	117	65	45	7
H. 0960 Stirling S. 11 × Grant ...	118	70	44	4
H. 0968 Stirling S. 11 × Grant ...	117	52	61	4
H. 0920 Bathsheba × Stirling S. 11	119	18	57	44
H. 0921 Bathsheba × Stirling S. 11	117	13	70	34
H. 0927 Balls × Stirling S. 11 ..	114	27	87	None
H. 0949 Balls × Stirling S. 11 ...	116	31	85	None
H. 0963 Balls × Stirling S. 11 ...	118	26	92	None
H. 0954 Silket 12 × Stirling S. 11	115	58	57	None
H. 0935 Silket 15 × Florida	120	49	68	3
H. 0937 Silket 15 × Florida	114	47	65	2
H. 0937 Silket 15 × Florida	122	56	64	2
H. 0910 Upton × Stirling S. 11 ..	105	49	35	21
H. 0966 Upton × Stirling S. 11 ..	109	33	56	20

As will be seen from the above table, in some instances, a large number, comparatively speaking, of the plants resembled neither the male nor female parent, and they varied among themselves from tiny plants, not 12 inches high, to others taller than either parent. In some instances the plants were devoid of fruit while others were fairly well laden.

Although very little beyond what is mentioned above can be said about the hybrids, one or two interesting results have been obtained on the seed selection plots. In one instance, Grant, a variety obtained from a peasant of that name living in the neighbourhood of the experiment plots, has, so far, steadily improved during the four years it has been under cultivation. In 1908, when the seed was first sown the length of the lint was only 36·1 mm. and the weak fibre 35·7 per cent. The next year the yield from the selected plant calculated to the acre was 2,376 lb. of seed-cotton, the length of the lint was 38·7 mm. and the weak fibre 26·7 per cent. In 1910, the yield of seed-cotton from the selected plant calculated to the acre was 2,938 lb., the length of the lint had gone up to 45·5 mm. and the weak fibre had come down to 16·1 per cent. In 1911, the yield under the same conditions had gone up to 4,406 lb. of seed cotton, the length of the lint to 46·2 mm. and the weak fibre had further come down to 14·4 per cent. On the other hand, with cotton obtained from other districts like Bathsheba on the sea-coast on the eastern side of the island, the results have not by any means been so satisfactory. On the land on which the experiments are being conducted the soil is, on the whole, of a very clayey character, and it would appear that with seed brought from districts where the soil is light the results have not been so good. As evidence that this is the usual result obtained with cotton when taken from a light soil to a heavier one, it may be mentioned that when cotton seed is taken from St. Vincent where the lint is fine and long, and planted in Carriacou where the soil is of a distinctly different character, the lint becomes much shorter than the St. Vincent cotton, and that when the seed is returned from Carriacou to St. Vincent the length rapidly increases again. As further showing the effect of soil conditions on the character of the cotton produced, I may mention that in 1903 when I was with Sir Daniel Morris, the late Commissioner of Agriculture, in the Sea Islands off the coast of South Carolina, I was told of two cotton plantations which adjoined, one of which always produced a better quality lint than the other even if seed from the same plot was planted.

With regard to the Grant variety, it may be stated that for the past three years, Mr. C. M. Wolstenholme, of the firm of Wolstenholme and Holland, of Liverpool, has been good enough to report on it as well as the samples of cottons obtained from other plants. In 1909 he valued the lint from the Grant at 11*d.* per lb. when the Sea Island grown under the same conditions was valued at from 14½*d.* to 15*d.* per lb.; in 1910 he valued it at 16*d.* when the Sea Island variety grown under the same conditions was valued at from 17*d.* to 21*d.* per lb. and last year he valued it at from 16*d.* to 17*d.* when the Sea Island grown under the same conditions was valued at from 17*d.* to 19*d.* per lb.

The following is a list of the cotton seed selection experiments at present carried on with the co-operation of planters:—

Sandford.	Dodds.	Upton.	Woodland.
B. H. 0944	Sea Island	B. H. 0968.	B. H. 0944.
Sea Island	Sakellaridis		Silket 33
			Sakellaridis
Stirling.	**Mt. Pleasant.**	**Fairy Valley.**	**Chancery Lane.**
S.	B. H. 0921	B. H. 0944	Sea Island
U.		Silket 122	Silket
Hybrid 1		Silket 124	Sakellaridis
Hybrid 2		Upton (Silket)	
		Sakellaridis	
Coverley.	**Union Hall.**	**Porters.**	**Pickering.**
Sakellaridis	Sakellaridis	Sakellaridis	Sakellaridis
	Grant		

The following is a list of varieties of cotton under cultivation on the Government Experiment Plots :—

B. H. 0916 ...	Grant × S.S. 11	Grant
B. H. 0944 ...	S. S. 11 × Grant	Stirling S. 1
B. H. 0954 ...	Silket 12 × S. S. 11	Stirling S. 1
B. H. 0963 ...	Balls × S S. 11	Stirling S. 11
B. H. 0966 ...	Upton × S. S. 11	Stirling S. 11
B. H. 101 ...	Grant × S. S. 11	Silket 33
B. H. 102 ...	Bathsheba × Heaton	Silket 37
B. H. 103 ...	Batsheba × S. S. 11	Silket 38
B. H. 105 ...	S. S. 11 × Bathsheba	Antigua
B. H. 111 ...	Balls × S. S. 11	C. 106
B. H. 112 ...	C. 106 × S. S. 11	Bathsheba
B. H. 113 ...	S. S. 11 × C. 106	Carrington
B. H. 114 ...	S. S. 11 × S. S. 11	Thornhill
B. H. 115 ...	S. S. 1 × S. S. 1	Florida
B. H. 116 ...	C. 106 × C. 106	Antigua
D. H. 28		Waterford
D. H. 35		Hy. Gilkes
Husbands		Heaton
St Croix		Egyptian Sakellaridis

The following is the report on the lint obtained from the hybrids as compared with Sea Island cotton :—

Report and valuation of cotton from selection plots (hybrids), Barbados for the season 1911-12 by Mr. C. M. Wolstenholme of Messrs. Wolstenholme and Holland, of Liverpool. when the average price of good Sea Island cotton was from 17*d.* to 19*d.* per ℔ :—

Name of cotton.	Classification and report.	Strength.	Value per lb.
B. H. 0944...	Dull, staple moderate fine fair length, little irregular.	Fairly strong	15-15½*d.*
B. H. 0966...	Dull, high colour, staple short and soft.	Rather weak	11-12*d.*
B. H. 0954...	Bright, moderate length, fairly fine	Mod'ly strong	15-16*d.*
B. H. 0963..	Very bright, regular, good length, rather wanting in fineness	Fairly strong	17*d.*
D. H. 28...	Bright, rather wanting in length and fineness	Mod'ly strong	15*d.*
D. H. 35...	Bright, staple short and wanting in fineness, wanting in Sea Island character	Fairly strong	12*d.*
B. H. 101...	Fairly bright, close moderate length, fairly fine	Strong	17-18*d.*
B. H. 102...	Rather dull, staple short rather irregular and wasty.	Mod'ly strong	14-15*d.*
B. H. 103...	Fairly bright, rather short wanting in fineness	Mod'ly strong	15*d.*
B. H. 105...	Bright, wanting in fineness and strength	Mod'ly strong	15-16*d.*

As showing the importance to Barbados of the cotton industry, I may mention that during the past five seasons, 1906-7 to 1910-11, there has been grown 28,824 acres of cotton which yielded, on an average, 1,529,870 lb. of cotton lint of the value of £285,746, and 11,144,421 lb. of seed of the value of £24,791, making a total of £310,537.

In conclusion, I may say that not only is the cotton industry in Barbados of importance as an industry in itself, but it is also very important for furnishing a remunerative rotation crop, especially for growing in suitable districts, in substitution for the sugar-cane in those fields in which that plant has been attacked by the root disease, *Marasmius sacchari*; and I consider that these experiments to which I have just been referring, and which have for their object the improvement of Sea Island cotton in Barbados, are of the highest value to the Colony.

COTTON SELECTION IN MONTSERRAT.

BY W. ROBSON,

Curator, Botanic Station, Montserrat.

The efforts at cotton selection, by which is meant the selecting, isolating and propagating of cotton plants with special qualities, have been carried on uninterruptedly at Montserrat since 1906. The earliest efforts were confined to the Experiment Station, but each year the scope of the work has been extended so that at the present time, the amount of work involved is as much as the staff at the Experiment Station can conveniently deal with. The actual methods of selection adopted are those outlined by Dr. Watts and Mr. Tempany in the *West Indian Bulletin*, Vol. IX, p. 220.

In some cases, and particularly where the soil conditions are peculiar, as for instance on soils tending to be clayey in texture. the actual work of selection has been carried out on the estate, the cotton from the special plants examined at the Experiment Station and the seed returned to the planter for propagation. In other cases where the soil conditions are similar to those at the Experiment Station, seed has been supplied of the strains of cotton showing the best records, grown there, and in the present season, practically all the cotton estates, have trial plots (some estates have as many as six) ranging from 1 to 6 acre in extent, on which strains of cotton directly derived from special mother cotton plants, are being tested for their suitability for general cultivation in that particular district.

As the results of the earlier efforts at selection in the Experiment Station, seeds from the breeding plots were distributed to certain estates, and a large area on the leeward side on the island in particular, has been planted for several seasons with seeds obtained originally from plants selected in the Experiment Sation.

At the present time the most comprehensive series of tests is being made at the Experiment Station* itself, where some twenty-seven strains are under experiment. The progeny row method of testing the yield is adopted and the plots are as far as possible duplicated, so as to minimize the experimental error due to variations in the character of the soil.

To avoid wrong conclusions with regard to the value of the various strains, samples of lint have been submitted from time to time to Mr. C. M. Wolstenholme of Manchester for report, and in 1911 the lint of seven of the strains under trial was also submitted to spinning tests by Mr. A. H. Dixon also of Manchester, so that taken in conjunction with the comparative yields, it is possible from the results to form a fairly accurate estimate of the value of the cottons grown.

Experience has shown that it is not an easy matter to obtain a strain of cotton that does not show some defect either in the

* Actually on land near the Experiment Station placed at the disposal of the Department by Messrs. Sendall & Wade's attorney, Mr. Penchoen.

field characters or in the lint, and it is of interest to point out that one of the strains under trial, namely Heaton No. 9, has during the last two seasons given good results in the field, the lint has been very well reported on, and it is expected that a considerable area will be planted with seed from this type in 1912.

In connexion with the cotton-breeding work it has been observed that occasionally, selected plants do not breed true. Three cases of this kind have been noticed, where in planting the seeds of a selected plant, a proportion of the resulting progeny have shown undesirable features, not apparent in the parent. These plants have been regarded as being hybrid in character, and on account of their instability, undesirable.

The following method of perpetuation of a particular strain is adopted. The seeds of the plant selected in 1909, marked Heaton No. 9 are planted in the breeding plot in 1910. In this year six of the plants are marked and the seed-cotton collected into separate bags, the lint is submitted to the usual tests and the seeds of the two plants showing the most desirable features are retained for planting in 1911. The two plants in 1911, which are labelled, Heaton 9 No. 3. and Heaton 9 No. 6 respectively are treated as if they were separate strains, and six plants are again re-selected and the seed-cotton collected separately, from both types, the lint of the twelve plants being subsequently examined. Thus the inheritance both for breeding qualities (yield) and lint characters comes into perspective, and the type showing the best all-round features is perpetuated. While this method of growing two plants together instead of one, of a particular strain of cotton, involves considerable trouble, it better enables the plant breeder to keep the best features in expression.

The introduction of new strains for trial is receiving attention, and it may be pointed out that while the direct introduction of seeds for extensive planting, into a new locality may be wrong in principle, the usefulness of new seed as a starting point for selection must be allowed.

While only bearing indirectly on seed selection of cotton, observations have been made during the last two years, with a view to showing what precautions are necessary to maintain the vitality of cotton seeds unimpaired, from the time of reaping, until they are required for planting in the following season. It has been shown that the germinating power of seeds can be entirely destroyed by the heating of seed-cotton and also when seeds are stored in bulk after ginning. The exact temperature at which the vitality is destroyed has not been ascertained. Although it has also been found that as a rule cotton seeds show a high germinative power as they come from the field, when the cotton is picked, this is not always the case, and it suggests the necessity for making germination tests before deciding which seeds are to be reserved for planting purposes. Thorough sunning of the seed-cotton before storing should obviate the possibility of heating, and subsequent to ginning the seeds should not be stored in large bulk. There are probably other factors involved in the deterioration that takes place in connexion with cotton seed that have not come under notice.

Since the above paper was written, the following report has been received from the Imperial Institute, regarding a sample of the Sakellarides cotton grown in Montserrat during last season :—

IMPERIAL INSTITUTE.

RESULTS OF THE EXAMINATION OF COTTON FROM MONTSERRAT.

Imperial Institute. No. 44,129. Date, 24th May 1912.

Reference. Letter No 12 dated 12 April 1912 from the Curator of the Botanic Station in Montserrat.

Number of mark and weight of sample. Egyptian Sakellarides Cotton grown in the Experiment Station at Montserrat. Season 1911-12. Weight, 6 oz.

Variety of cotton. Sakellarides.

Description. Ginned cotton, clean, lustrous, soft silky, cream-coloured and free from stains.

Strength. Mostly good but slightly uneven.

Length of fibres. From 1·1 to 1·8 inch ; mostly from 1·4 to 1·6 inch.

Diameter of fibres. From 0·00045 to 0·00090 inch ; average 0·00060 inch.

Microscopical characters. The fibres showed a fair amount of twist and appeared to be fully mature.

Commercial valuation. 12½*d.* per lb., with 'fine' Yannovitch at the same price.

Remarks. This sample is of excellent quality, and shows all the usual characteristics of Egyptian Sakellarides cotton. It is rather stronger than any sample of this variety proviously examined at the Imperial Institute. The result is very encouraging and indicates that Sakellarides cotton might be well worth cultivating in Montserrat on a commercial scale.

THE MANNER OF CROSS-POLLINATION OF COTTON IN MONTSERRAT.

BY W. ROBSON,

Curator, Botanic Station, Montserrat.

The investigations of workers with the cotton plant in various parts of the world have recently resulted in statements being made to the effect that cross-fertilization in cotton flowers takes place to a much greater extent than is commonly supposed, and that the agents are almost exclusively insects.

In a crop like cotton, where purity of strain is one of the principal objects aimed at, it is incumbent on the plant breeder that he should fully appreciate the possible effects of cross-fertilization.

The selection, isolation and propagation of specially good individual plants is the recognized method of obtaining seed for introduction into general cultivation, and the way in which the phenomenon of cross-fertilization may affect the ultimate results is best illustrated by the following example. Let us suppose that a pollen grain from a degenerate and undesirable cotton plant reaches and fertilizes the ovules of a specially desirable individual. The resulting seed in the next generation produces a plant showing all the desirable characters, those which are undesirable remaining unexpressed. This particular plant being chosen for propagation, a proportion of the resulting progeny shows the undesirable characters of the grandparent referred to, and considerable trouble would be involved in again establishing a stable race of the desirable plants. Two cases of this kind appear to have occurred in connexion with the cotton-breeding work in Montserrat.

With a view to deciding to what extent natural agencies are operating to bring about the cross-pollination of cotton under the conditions obtaining at Montserrat, preliminary observations were undertaken in 1910. A large number of insects were found to be associated with the cotton plants, such as the Jack Spaniard (*Polistes* sp.), lacewing flies (*Chrysopa* sp.), lady-birds, grasshoppers, Syrphus or hovering flies and many others.

More closely associated with the flowers were beetles, ants, honey bees, one or more species of small Dipterous flies, an unidentified species of thrips, and a large bee identified as the female of *Dielis dorsata*. Only two of these insects appear to be responsible for the dissemination of pollen to any extent, namely the Dielis bee and the small thrips. The Dipterous flies mentioned are occasionally numerous in cotton flowers, but they show very little disposition to fly from one to another, and are consequently of little importance, except that they may aid self-fertilization to a slight extent. The thrips are of interest but only from the point of view that they also play some part in self-fertilization. The anthers of the Sea Island cotton were found to dehisce before dawn, and at a very early hour, even before the corolla had opened, the small thrips were found to be busy at work, apparently having entered the flowers between the folds of the corolla which,

as yet, had not expanded. These small insects have been found in the majority of cotton flowers examined. They clamber amongst the pollen masses, which becoming attached to their bodies, are left behind as the insects move about on the stigma. The observations showed that only a small quantity of pollen is carried by them on to the upper half of the stigma, so that fertilization in the majority of cotton flowers is effected from the section of the stigma nearest the ovary.

The bee referred to as *Dielis dorsata* was the only insect observed in 1910 to be carrying pollen from one flower to another. It is a powerful insect, similar in size and shape to a queen honey bee. It was present in many localities of the island, and in the vicinity of the Botanic Station, during the whole of the flowering period of the cotton plants. This bee, while it evidently prefers to enter the open flower in search of nectar, has also acquired the habit, as in the case of the honey bee, of occasionally making its way between the bracts and the corolla, the interior of the flower being visited, in the large majority of cases. It is on emerging from the flower that this insect as a rule comes in contact with the stigma, covering it with masses of pollen grains. The opinion was formed that the number of flowers with the stigmas of which the bee had been in contact could be determined by the yellowness caused by this covering of pollen grains, particularly of the upper part of the stigma. One hundred flowers were examined on each of eight separate days in October—the middle of the flowering period of the cotton plant—and the average percentage thought to be cross-pollinated was 21, ranging from 4 on a dull, showery day to 33 per cent. on a bright day.

As the result of further observations in 1911, two more species of bees have been found in certain localities to be frequent visitors to the cotton flower. These are *Centris haemorrhoidalis* and *Megachile* (?) *martindalei*. These insects enter the open flower in a manner similar to that of the Dielis bee, but on account of their slightly smaller size are probably not so effective as pollen distributors. The Dielis bee has been as numerous in 1911 as in the former year. All the species mentioned fly very quickly from flower to flower, as many as six to eight being visited in the course of a minute. It should be mentioned however that the insects do not come into contact with the stigmas of all the flowers visited. It seems very likely also that the numbers of these classes of insect vary greatly in different localities.

While these observations are of interest as indicating that a certain amount of cross-fertilization is probably taking place in cotton fields, the actual amount of hybridization is a much more difficult matter to determine. With this in view, a plot of cotton composed of the two varieties, Sea Island and Nevis Purple, the latter a local variety, was planted in the Experiment Station in July 1911. The underlying idea was that, as the red colouration of the Nevis Purple variety is dominant and thus shows itself in the seedlings when the two varieties are crossed together, it would be possible by sowing all the seeds produced by the Sea Island plants to find the actual percentage of hybrids in the seedling stage, as they would in this case all show the red

colouration of the Nevis Purple type. This plot has up to the time of writing yielded no results, on account of the late flowering habit of the Nevis Purple variety.

Another method of deciding what amount of cross-pollination is taking place, has suggested itself to the writer. Occasionally, Sea Island plants are met with that carry cream-coloured instead of bright-yellow pollen, the normal colour. Presumably these plants with cream-coloured pollen will breed true; thus by planting the two strains, yellow-pollened and cream-pollened, together, it would be possible by carrying out regular observations on the cream-pollened plants to form a general idea as to the amount of cross-pollination that occurs.

SAKELLARIDES COTTON IN MONTSERRAT.

BY W. ROBSON.

Curator Botanic Station, Montserrat.

As considerable interest attaches to this type of cotton at the present time, it may be useful to record the result of preliminary experiments that have been conducted at the Experiment Station in Montserrat during the present cotton season, 1911-12.

Two lots were received through the Imperial Commissioner of Agriculture. The first supply, a mere handful, was planted on July 22, forming a plot $\frac{1}{25}$-acre in extent. A larger supply received on August 7 was planted on the 11th of the same month. This plot (b) occupied $\frac{1}{4}$-acre.

It should be stated that the conditions at the Grove Experiment Station are particularly favourable for the growth of cotton, generally; the soil is light in character, and well sheltered, and the plots a and b were in a fair condition of fertility. Plot a received a normal application of sheep manure, sulphate of potash and superphosphate just previous to planting, while plot b carried a heavy dressing of Bengal beans in 1910, which was buried. The weather conditions were, on the whole, favourable, except that frequent rains in December and early January interfered with the ripening of the bolls on plot b.

The young Sakellarides cotton plants, for a few weeks after germination, showed a striking contrast to those of the Sea Island type, in that they presented a lanky, drawn up appearance. A somewhat straggling habit was characteristic of them also in the later stages. The leaves, flowers and essential organs were not observed to differ in structure or form from these characters in Sea Island plants. The laterals, which are slender and somewhat pendulous, are regularly developed from the base, upwards. Basal branches, which tend to grow horizontally, were a marked feature. The plants

developed a strong central stem, the internodes were long and ultimately the plants grew tall. The habit and general appearance, on the whole, approximated very near to plants of the Sea Island type.

The bolls, which are usually three-locked, have a puffy appearance more nearly resembling the Upland than Sea Island cotton. The cotton lies very loosely in the mature boll, and while this facilitates reaping, it greatly endangers the cotton, on account of its being easily blown from the boll. In weather favourable to the opening of the bolls, seven days between reaping was found to be too long an interval to ensure the cotton being collected before it began to fall from the bolls.

The plants proved to be tolerably free from disease. There was very little evidence of the bacterial disease, *Bacterium malvacearum*. Leaf-blister mite attacked the plants readily and cotton stainers were troublesome. The loss of bolls, owing to imperfect development, which is so marked a feature in Sea Island cotton, was less evident in the case of the Egyptian plants.

The yield of seed-cotton from plot a was at the rate of 1,475 lb. per acre, and plot b up to the time of writing has yielded at the rate of 780 lb. per acre. A little cotton still remains to be reaped on the last-mentioned plot, possibly 150 lb. per acre.

In considering the results, due allowance must be made for the late season at which the plots were planted, the months of May and June now being regarded as the most satisfactory for the planting of Sea Island cotton, at least in Montserrat The behaviour of the plants, on the whole, indicates that this type will prove to be a hardier and a heavier cropper than the Sea Island cotton. A series of nine tests, made at different periods, with a view to deciding the number of bolls required to make a pound of seed-cotton, showed an average of 138 bolls per lb. Compared with observations on Sea Island plants, it means that the bolls of the Egyptian type yield slightly more seed-cotton, on the average, than most strains of Sea Island cotton.

The average lint length on thirty-six plants examined was 37·2 mm. or about $1\frac{1}{2}$ inches. Four plants averaged 35 mm., four, 36 mm., six 37 mm., eighteen 38 mm and three 39 mm.

Tests for percentage of lint on seventeen selected plants showed an average of 30, and the percentage of weak fibre eliminated by means of the weaver's comb used in connexion with the selection of Sea Island plants, was 11·8—a very low figure compared with the results from Sea Island plants.

A noticeable feature about the lint of the Egyptian type, which in colour resembles Sea Island, is its remarkable strength.

THE COTTON BOLL WEEVIL.

BY H. A. BALLOU, M.Sc.

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The information contained in this paper is based upon published accounts of this insect mostly to be found in the bulletins of the Bureau of Entomology of the United States Department of Agriculture.

The cotton boll weevil (*Anthonomus grandis*, Boheman,) does not occur in the British West Indies, but on account of its capacity for injury, and the possibility that this insect may yet become established outside the countries at present infested, a short note on the remarkable spread of this pest in the United States may be of interest.

The cotton boll weevil has been known as a pest of cotton since 1894, when it was discovered in Texas, having been introduced some two years previously from Mexico. At the present time it is known to occur throughout Mexico, Central America, and in Cuba.

The species was first described in 1843, from Vera Cruz, Mexico. It was recorded as occurring in Cuba in 1871. In 1885 Professor Riley recorded the fact that beetles of this species had been reared from dwarfed cotton bolls received at Washington from a correspondent in Northern Mexico. This was the first time that this insect was in any way associated with cotton.

When the presence of a destructive pest in the cotton fields of Southern Texas was reported, energetic measures were at once adopted with a view to ascertaining all the facts of its life-history, habits and natural enemies. The seriousness of the situation was early recognized and Professor Riley of the United States Department of Agriculture advised the Government of the State of Texas to prohibit the growing of cotton throughout the infested area and for a short distance beyond, in order to prevent the further spread and thus save the entire cotton belt from invasion. It was predicted that unless some such step were taken the boll weevil would continue to spread until every cotton-growing district in the country was infested.

The prediction is being gradually realized; no remedies in the way of poisons which are effective against this pest are known and no natural enemies occur in sufficient numbers materially to check its advance.

The United States Department of Agriculture has issued a chart exhibiting the spread of the boll weevil each year from 1904 to 1910, which shows that at the end of the cotton-growing season of last year the boll weevil was known as far east as the western border of Florida and nearly to the centre of Alabama.

During the seventeen years since the boll weevil was discovered in the United States, it has spread over a distance of about 850 miles in an easterly direction, and nearly an equal

distance to the north. The spread to the west has been very much less. The distance to be traversed by this insect from its eastern limit at the end of 1910 to the nearest point on the Atlantic coast is only about 150 miles, and it seems safe to predict that this distance will be covered at about the same rate per year as that at which it has advanced during the past few years. This distance is almost exactly the same as that covered by the progress of the boll weevil from the end of 1905 to the end of 1910, along the coast of the Gulf of Mexico. This would indicate that at the end of 1915 the boll weevil would be found in the cotton fields on the Atlantic coast in the State of Georgia at least, and its subsequent extension throughout Florida on the south, and through North and South Carolina on the north is a matter of only a few years more.

Destructiveness.

The boll weevil is probably the most destructive insect pest which has ever attacked agricultural crops. It has been estimated in recent years that the loss in the cotton crop in the State of Texas alone has reached a value of $15,000,000 to $22,500,000 in a year. The immediate effect on the cotton crop of the invasion of the boll weevil is to reduce the crop by fully one half for a number of years, and if this reduction of 50 per cent. were applied to the whole cotton crop of the United States, it would mean an annual loss to the cotton growers of more than $250,000,000.

If Professor Riley's recommendation had been acted upon for a few years immediately following the year 1905, it is quite possible that the boll weevil in the United States would have been restricted to that small area bordering the Rio Grande river in Southern Texas, where it was known to occur at that time.

Means of Spread.

The natural spread of the boll weevil by flight in the extension of its feeding area would probably not account for the rate at which it has travelled across the United States from west to east. One of the most common of the means by which this insect has been dispersed is probably to be found in connexion with the transportation of seed-cotton and cotton seed to and from ginneries, especially when cotton seed has been sold for planting from ginneries near the borders of the infested territory. Seed-cotton from infested areas has been taken to these ginneries, and the seed sold for planting in adjoining districts which up to that time had not been infested, and the weevils established in new territory in that way.

It has been found also that cotton which has been ginned and baled, cotton seed shipped to oil mills, and cotton seed hulls and other by-products sold to farmers have all been instrumental in spreading the weevil into new territory.

Cotton seed which has been carefully examined has disclosed the fact that boll weevils are able to pass through cotton gins and come out alive. This would show that a con-

siderable amount of danger is attached to the shipment of cotton and cotton products from infested to non-infested areas, and should serve to indicate the caution that ought to be taken in such cotton-growing localities as the West Indian Islands, with regard to the importation of any such commodity.

Treatment with carbon bisulphide will probably result in the death of the cotton boll weevils in cotton seed which it is desired to use for planting, provided that the seed is treated in small quantities, and that special apparatus is used for the operation. This special apparatus consists of a force-pump by means of which the fumes of the carbon bisulphide are forced through the seed in such a manner as to penetrate into every space. No guarantee can be given, however, that all the weevils in such treated seed are killed. The best that can be said of it would be that it probably contains no living weevils.

Cultural Methods.

Probably the most effective single operation in the control of the boll weevil in infested areas depends on early planting, which allows for early ripening of the crop and the early destruction of the cotton plants. It has been found that when old cotton is allowed to remain in the field and provide a suitable place for hibernation, the boll weevil is able successfully to pass the winter in the coldest localities which have yet been invaded by it, but when cotton plants, corn stalks, and weeds of all descriptions are carefully cleared away from the field and their borders, the attack of the weevil in the following year is much less severe. In this case the weevils are less numerous, probably on account of the difficulty of successful hibernation. The practice of wider planting to enable the sun's rays more effectually to reach the soil, and the use of farm implements to drag out from beneath the plants into the open space between the rows all fallen bolls and squares in order that they may be quickly dried up by exposure to the sun, have been demonstrated to be extremely useful in this connexion.

A system of crop rotation has also been found useful in improving the agricultural conditions in infested areas, and reducing the severity of boll weevil attacks. It is quite possible that many districts in which formerly only a single crop —cotton—was grown, will ultimately be very much benefited by a wider agriculture and improved methods of farm practice.

Natural enemies, including parasites, predaceous insects, birds and other forms of animal life probably have some influence in reducing the numbers of boll weevils in the infested territory, but their influence is not sufficient to effect any great good in the control of the pest.

The Effect of Climate.

It is a fact worth remarking that the boll weevil has spread into the regions of greater moisture, lying in an easterly direction rather than into those cotton-growing districts to the west,

which are drier. It would seem from this that rainfall and moist atmospheric conditions are favourable to the development of this insect. Professor C. H. T. Townsend has found in Peru a weevil of the same genus (Anthonomus) which, in that country, attacks the cotton squares in a manner similar to that observed in the case of the boll weevil in the United States. Professor Townsend has found that this insect has seriously interfered with the cotton cultivation in very moist districts and at certain moist seasons in the drier districts in that country. This, together with the records of the spread of the boll weevil in the United States, leads Professor Townsend to the opinion that both the boll weevil in the United States and the cotton square weevil in Peru will cause much less serious injury to the cotton crop in dry than in humid districts.

Effect on Cotton-growing in the West Indies.

The invasion of the entire cotton-growing area in the United States by the cotton boll weevil will probably have a beneficial effect on the prospects of cotton-growing in the West Indies. The output of Sea Island cotton from South Carolina and of the Georgia and Florida Sea Island cotton is likely to be greatly reduced for several years immediately following the advent of the boll weevil in these districts.

Florida and Georgia are about to be invaded, if indeed, this has not already happened during the cotton-growing season just closed, and it is probably a matter of not more than four or five years until the same will be true of the islands of South Carolina.

If the amount of crop in these localities is reduced by one half, as has been the case in Upland cotton districts already infested, it would seem that the market for Sea Island cotton ought to be strengthened to a very considerable extent.

If, on the other hand, the cotton boll weevil should by any unfortunate circumstance be introduced into the West Indies and become established in these islands, the result would be most disastrous. It does not seem likely at the present time that the cotton industry would be able to survive such a catastrophe. Very few growers of cotton would carry on the fight against this destructive insect in the face of the prospect of greatly reduced crops over a period of years, the length of which no one could foretell with any degree of certainty. The advent of the boll weevil would mean in addition to reduced crops, increased expenditure on cultural operations, and probably much improvement in cultural methods on most estates. It would be necessary to establish a definite close season for cotton during which season no cotton plant which had arrived at the flowering condition should be allowed to stand in the fields in any district and this might even apply to an entire island. It would be necessary that the rows in a field should have wider spacing, and that implemental or hand labour should be employed to drag out from beneath the plants into the spaces between the rows, all fallen bolls or squares.

All these extra operations must be associated with extra expense, and it is extremely probable that the great majority of cotton planters would turn their attention to some other crop rather than meet these expenses, especially with the prospect of producing at the same time only half as much cotton per acre as is being produced at present.

It would be necessary also to destroy all wild or native cotton in any island or district invaded by the cotton boll weevil, in order to exercise any satisfactory degree of control over this pest.

There are no doubt many insects in the West Indies which in time would become enemies of the boll weevil, and there is a possibility that in those islands with a very dry climate this insect might not make a rapid development. The chances are, however, that the cotton-growing industry would not survive the time necessary for the native parasitic and predaceous insects to become accustomed to the boll weevil as a host, and there can be no certainty that the climatic conditions would be such as to interfere seriously with the development of this pest.

The conditions of the cotton-growing industry in the West Indies are such, however, that there should be little or no danger of the introduction of the cotton boll weevil into these islands. At the present time there would seem to be no necessity for the introduction of cotton seed for planting into any island of the West Indies. In each of the cotton-growing islands there is already established a type of cotton well adapted to the conditions of soil and climate of that island.

Experiments are being carried out by means of hybridization and selection of plants in the field which, if persisted in, should always result in maintaining for each locality a satisfactory type of Sea Island cotton. The importation of seed-cotton and of cotton seed for oil production, from any district in which it was possible that the boll weevil might be established, would be a great mistake, if nothing worse.

Each island in the West Indies is provided with legislation by means of which imported plants likely to be infested with insect pests may be fumigated or otherwise disinfected upon arrival. If it should be deemed advisable to import valuable cotton seed for planting, this should only be done under the most careful conditions of supervision and control. Such seed should be accompanied by a sworn statement that it was produced in a locality in which the boll weevil was not known to occur. Another certificate should accompany it, stating that it had been fumigated by the method known to be most effective for the destruction of the boll weevil, and on its arrival this cotton seed should be subjected to another treatment of the same kind. Even with all these precautions it is possible to a slight extent that the boll weevil might be introduced with cotton seed from any part of the United States, from Central America and Mexico, or from Cuba, and that all the disinfection by fumigation or otherwise to which such seed could be subjected might not be sufficient to prevent the introduction of living boll weevils.

NOTES ON CERTAIN COTTON PESTS.

BY H. A. BALLOU, M.Sc.

At the last Agricultural Conference held in Barbados in January 1908, I stated that the pests of cotton had been the same during the preceding year as in the two previous years 1905 and 1906. It was noted, however, that an insect had made its appearance toward the end of 1907 in Antigua which caused flower buds to drop, and which might possibly become a serious pest.

This insect has come to be known as the flower-bud maggot, and is the only insect which has caused any serious damage to cotton in addition to the pests that were well known previous to the end of 1907.

In addition to a brief account of the flower-bud maggot, it is proposed in these notes to mention only two of the previously described pests of cotton, not because of any serious outbreaks that have occurred, but rather because of certain interesting developments in connexion with their control.

The Flower-bud Maggot.

The flower-bud maggot (*Contarinia gossypii*, Felt) made its appearance, as has already been stated, about the end of 1907, becoming a serious pest in Antigua during December of that year and the January following. It occurred in all parts of the island and nearly every field of cotton was attacked.

The amount of damage to the cotton crop of 1907-8 resulting from the attacks of this insect was probably equal to about one-half of the total crop of the island, and this had a very strong influence in bringing about a greatly reduced acreage of cotton in the following season (1908-9).

An account of the flower-bud maggot and its occurrence in the two cotton seasons 1907-8 and 1908-9 was published in the *West Indian Bulletin*, Vol. X, pp. 1-28. It may, however, be of interest to mention a few points in connexion with this insect and the nature of the injury resulting from its attack.

The flower-bud maggot belongs to a group of two-winged flies, the Cecidomyiidae or gall midges. This family of insects includes some of the most troublesome of pests, and they attack nearly all parts of growing plants. Each species, however, usually inhabits some particular portion of the plant, many of them living in the flower, or bud, or fruit. Specimens of the flies reared from the infested flower buds of cotton were submitted to Dr. Felt, the New York State Entomologist, who is an authority on this group of insects. Dr. Felt found that it was a new species, and described it under the name *Contarinia gossypii*.

The flower-bud maggot attacks the very young flower bud of the cotton plant. It is not known to occur in any other part of the plant, and so far only one other food plant of this insect is known. This is the wild coffee or privet

(*Clerodendron aculeatum*), in the flower buds or flowers of which *Contarinia gossypii* has been found to exist.

This species of insect is best known by the injury it causes and by the appearance of the bud, which indicates the presence of the larvae in the bud before it drops. The larvae may often be found in the buds, but the pupae and adults are almost never to be seen in the field. The pupae occur in the ground, and are so small and inconspicuous as to make it difficult to find them. The minute flies (from $\frac{1}{16}$ to $\frac{1}{8}$ inch in length) are rarely if ever seen in the field even in the cases of most severe attack. Sweeping with the insect net among the infested plants and the weeds and grass in the field, and also its borders, results in the capture of a great variety of insects, large and small, but the Contarinia is very rarely among them.

The eggs of the flower-bud maggot are not known, but it is believed that they are deposited within the tissues of the flower bud of the cotton, by means of the long ovipositor with which the female fly is provided, at a very early stage of its development, the maggots which result from the hatching of the eggs feeding on the tender material of the developing stamens and pistil. As many as forty-three maggots have been counted in one small bud. The injury is sufficient, generally, to cause the bud to drop while quite young, although sometimes it remains on the plant long enough for the flower to open partially, but it is not likely that a cotton boll can ever be developed from such a bud. When the bud drops, the maggots immediately make their way into the ground, where they pass the pupal stage and transform to the adult condition. The entire life-cycle probably occupies from twenty-four to thirty-one days.

This insect has been reared from cultivated cotton, from wild or native cotton, and from wild coffee (*Clerodendron aculeatum*). It is known to occur in Antigua and has been reported from Montserrat. It was a serious pest of cotton in Antigua in 1907-8 and in 1908-9. In 1909-10 it was scarcely noticeable. In the early part of 1911 at the end of the 1910-11 cotton season, this insect was found in a few localities in Antigua. The attacks were mild in character, but long in duration, since the last occurrence was late in April, whereas in other seasons the attacks were over early in that month. The attack of the flower-bud maggot in Montserrat in January 1909 was very slight. It is reported as occurring in that island at the end of 1911 (i.e. during November). These attacks are the only recorded occurrences of the flower-bud maggot on cotton, and this insect seems to be the only Cecidomyiid fly attacking cotton in this manner.

Experiments in the use of insecticides and the application of direct remedial measures have given negative results in every instance. The occurrence of the flower-bud maggot seems to be associated with certain climatic conditions that often prevail in Antigua toward the end of the year. These consist of periods of more than ordinary dampness accompanied by cool nights. Early planting, to enable the bulk of the crop to become developed before these conditions are brought

about, seems to be the only remedy so far known. This would mean planting at a time which would enable most of the bolls on the plants to be formed not later than the middle of October.

The Cotton Worm.

It is not necessary to enter into any account of the cotton worm (*Alabama argillacea*). Its appearance and habits, the amount of damage it can do, and the means of control usually practised, are too well known to need any further comments at this time.

The interesting aspect of the cotton worm question is to be found in the great scarcity of this pest during the two cotton seasons 1909-10 and 1910-11, and the comparative scarcity during the present season. During the season of 1909-10 very few cotton growers in the West Indies found any difficulty in keeping this pest in check, and very little money was expended for Paris green. During the following season the experience of cotton growers was similar, but in a few instances rather severe attacks were experienced during October and November 1910. During 1911 attacks of the cotton worm have been more frequent and of greater severity, but these do not seem to be so frequent nor so abundant as in the earlier years of the cotton industry.

There can be no doubt that this remarkable decrease in numbers which has been so noticeable in these seasons is due to the action of natural enemies. These natural enemies are of two kinds—internal parasites and predaceous insects.

The internal parasites are egg parasites and parasites of the larva and pupa. There are probably at least two species of egg parasites which attack the eggs of the cotton worm, *Trichogramma pretiosa* and *Telenomus* sp., and two or three parasites which attack this insect in its larval or pupal condition. The following species of these are known in the West Indies: the flesh fly (*Sarcophaga trivittata*) one or more Tachinid flies and the hymenopterous insect *Chalcis annulata*.

There are several insects which prey upon the cotton worm, and which are probably extremely useful in this connexion. Chief among these are the wasps known as Jack Spaniards, Wild Bees, Marabuntas, etc. In St. Vincent, where the cotton worm has been known to exist in the cotton fields for several years, it has not been necessary to apply insecticides or adopt any other remedial measure, the pest being kept entirely in subjection by the action of its natural enemies. The chief credit for the control of this pest is given by the St. Vincent planters to the Jack Spaniard. The wild bee of Barbados and the Jack Spaniard of St. Vincent are *Polistes annularis*. The cow bee (*P. bellicosus*) and another species which is sometimes called the Marabunta or Jack Spaniard (*P. fuscatus instabilis*) are probably both useful in this connexion.

There are several other insects that prey on the cotton worm, but probably none of them are capable of accomplishing

so much good as the Jack Spaniards. The fiery ground beetle (*Calosoma calidum*) is recorded from St. Vincent and Barbuda. This insect in both its larval and adult state attacks the cotton worm. In this connexion also it must be remembered that there are in the West Indies several species of birds which probably exert a considerable influence in the control of the cotton worm. In Barbados, the Barbados blackbird (*Quiscalus fortirostris*) is most useful in this connexion. This bird is gregarious and often may be seen in large flocks, in the early morning, in cotton and corn fields, feeding on the insects attacking these plants.

The Black Scale.

The black scale (*Saissetia nigra*, Nietn.) has been, in certain seasons, one of the most serious of the pests of cotton. In Barbados in 1905-6 entire fields of cotton were destroyed by this insect, and at the Agricultural Conference in January 1908, the black scale was mentioned as having been a serious pest during the season 1907-8.

During the period which has elapsed since that time, however, the black scale has come to be regarded, in Barbados at least, almost as a harmless insect. This change has come about apparently as a result of the enormous development of an insect parasite.

In 1906 Mr. Stockdale, then Mycologist on the Staff of the Imperial Department of Agriculture, and the writer, visited cotton fields in the parish of Christ Church, Barbados, where the black scale was very abundant. The manager of one estate told us that the white scale was the cause of greater injury to his cotton, although it seemed to be less abundant than the black scale. From the fields of this estate specimens were collected from which were reared the adults of the parasite which were afterwards described as *Zalophothrix mirum*, Crawford. For three years previous to this time, it was realized that the black scale was parasitized and the pupa had often been secured, but the adult of this insect was not known. It may be remarked that specimens of *Zalophothrix mirum* were collected by Mr. Lefroy in 1902, but there are no records to show that he recognized the insect as a parasite of a scale insect. Since 1906, this beneficial insect has enormously increased in numbers, and it has assumed an almost complete control of the black scale. It is also parasitic on related scale insects such as *Saissetia hemisphaerica* and *S. oleae*, and it has been reared from one or more species of the wax scale (Ceroplastes).

It has been found when the black scale makes its appearance in a field of cotton that it is possible to introduce the parasite by artificial means, and thus to check the development of the scale to such an extent that very little loss of crop is sustained. Barbados planters, acting on the advice of Mr. Bovell, have learned to collect from Hibiscus or other plants twigs bearing parasitized scales for the purpose of introducing them into the cotton fields as soon as the black scale makes its

appearance. They are tied in among the branches of the cotton plants where the scale attack is most noticeable, and it is reported that very good results have followed this line of action.

A few years ago, cotton growers were advised to destroy in the vicinity of cotton fields all plants known to be liable to attack by the black scale. Since the parasite of the black scale has become so numerous this course does not seem necessary. Black scale occurring on plants other than cotton may easily be made a source of supply from which to obtain parasites when these are needed. Planters should, however, thoroughly satisfy themselves that the parasite is well established on these scales.

The shield scale fungus (*Cephalosporium lecanii*) is also a parasite which exerts a very considerable influence on the abundance of the black scale, especially during the wet season. This control is not so marked in the case of the black scale on cotton as it is in the case of this and other, nearly related, scales on plants of a more permanent character. The very thorough destruction of these insects however on other plants prevents in a large degree the rapid infestation of cotton fields, by reducing the number of scales on those plants which might act as a source of infection.

If black scale occurs in any appreciable amount on old cotton at the end of the season, an opportunity should be given for as many as possible of the parasites to emerge from the scales. The cotton should be cut or pulled as soon as the crop is finished, and the plants piled from ten to fourteen days before they are burned.

This is the most remarkable instance in the West Indies of the control of a serious pest by natural enemies, and it is of especial interest since the degree of control is capable of being greatly increased by a small amount of assistance in distribution into new localities. It does not appear that the same degree of control is exercised over the black scale by the *Zalopothrix mirum* parasite in all the other West Indian Islands as in Barbados. On the other hand, the black scale has probably been a far more serious pest of cotton in Barbados than in any of the other islands.

OUTLINE OF MANURIAL EXPERIMENTS ON COTTON IN TOBAGO.

BY JOSEPH DE VERTEUIL, F.C.S.,

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Manurial experiments on cotton are being made at Old Grange estate, in Tobago. These experiments are under the control of the Board of Agriculture.

There are six plots of ½-acre each, including one control plot to which no manure was applied.

The manures are supplied free of cost to the proprietor, but the cost of application as well as the cost of cultivation are borne by the estate owner.

The soil is a red loam, and the seeds from Thornton's hybrid were planted at a distance of 8 feet by 5 feet during the first week of August 1911. Two weeks later the manures were spread around each plant and lightly hoed in.

The following experiments are being made :—

	Manures applied per plot.	Cost of manures per plot. (Landed in Port-of-Spain) $ c.
1	168 lb. basic slag 112 lb. kainit 56 lb. calcium nitrate	3 42
2	112 lb. bone meal 56 lb. sulphate of potash 112 lb. calcium nitrate	5 59
3	112 lb. bone meal 112 lb. kainit	2 77
4	168 lb. superphosphate of lime 28 lb. sulphate of potash 56 lb. sulphate of ammonia	5 04
5	168 lb superphosphate of lime 56 lb. calcium nitrate	3 75

COTTON EXPERIMENTS IN BRITISH GUIANA

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Trials of Cotton Varieties.

The trials with different kinds of cotton as reported at the last Conference (see *West Indian Bulletin*, Vol. IX, pp. 213 - 14) were continued in 1908. The results were as follows :—

Variety.	Yield in lb. of seed-cotton per acre.
Egyptian Jannovitch ...	100
" Metaffi	136
Buck cotton (indigenous) ...	280
Caravonica kidney cotton	235
Caravonica silk cotton ...	201

The weather conditions in 1908 proved disastrous to the production of cotton and as in no year, with the possible exception of 1907 in the case of Caravonica silk cotton, the yield of no variety was sufficiently high to cover the costs of cultivation it was not considered necessary to continue further the comparative trials with introduced and other varieties.

Since 1908, the experiments with cotton have been mainly directed towards the production of hardy varieties suitable for cultivation on the heavy clay soils of the coastal region of the colony under the meteorological conditions there prevailing.

In 1907, 120 hybrids between introduced Sea Island and an indigenous Buck cotton were raised, and of these 103 were planted out into the fields in 1908.

Careful records were kept of the characters of different plants and of their produce. The characters recorded of the two parents are as follows:—

	Sea Island, female.	Buck, male.	S I × B—F1.
	Field characters.		
Plant :—			
Habit	Bushy (d)	Open (o), tree-like	Open (o)
Height	5 feet	10-12 feet	4-10 feet
Maturity	Early (e)	Late (l)	Intermediate between parents (int)
Stem colour	Green (gr)	Purple (p)	Reddish purple (p) but of not quite such a dark shade as the male parent. Three plants showed pure green like female parent and four others were red faintly tinged with green.
Leaf :—			
Petiole Colour	Green with slight reddish tinge (gr)	Dark-red to purple (p)	Dark-red (dr)
Blade colour	Green (gr)	Purplish red (p)	Intermediate between parents (gr. pr.)
Veins	Green (gr)	Dark-red (dr) hairy	Red, (r) hairy
Stipules, hairy or not.	not	hairy	hairy
Shape of blade	3-5 partate	3-5 partate	3-5 partate
Hairy or glabrous	hairy (h)	hairy (h)	hairy (h)

	Sea Island, female.	Buck, male.	S I × B--F1.
	Field characters.		
Flower :--			
Bracts, size	medium (med)	large (l) deeply divided	large (l) deeply divided
Size of flower	medium (med)	large (l)	large (l) (9 medium)
Calyx teeth	long (l)	short (s)	short (s)
, thickness	moderately thick	thin and papery	intermediate (int)
Corolla colour	light yellow (l. y)	deep yellow (d. y)	light yellow (l.y)
„ spot	medium light to deep red	absent	present (sometimes small) pale to dark-red (lighter than in female parent)
Stamens, filaments	short (s)	long (l)	long (l)
Column	long (l)	long (l)	long (l)
Pollen, colour	orange	deep yellow (d.y)	deep yellow (d.y)
Fruit :–			
Bolls, shape	long, pointed, angular (l.p.a)	long, pointed, round. (l.p.r)	long pointed, generally angular like female parent (5 smooth, resembling Peruvian)
Bolls, distribution	regular (r)	at top of plant (irr)	regular (r)
Disease resistance	liable to anthracnose (p)	good (g)	good (g)

	Sea Island, female.	Buck, male.	S I × B—F1.
Lint :—	Lint characters.		
Proportion of lint to seed, per cent.	54·2	46	
Maximum length	42 mm.	28 mm.	mean maximum —38·1 (mm) (1 under 32 mm.)
Average length	38·3 mm.	26 mm.	mean—35·2 mm. (1 under 30 mm.)
Regularity of distribution	good (g)	good (g)	good (g)
Regularity of length.	good (g)	good (g)	good (g) 4 irregular
Density	irregular (irr)	regular (r)	rather irregular (irr) (9 regular)
Colour	white (wh)	white to creamy white	white (1 white to cream)
Strength	poor (p)	good (g)	medium to good (4 poor)
Silkiness	good (g)	poor (p)	good (g) (5 coarse)
Lustre	good (g)	fair (f)	good (g) (12 fair)
Seed :—	Seed characters.		
Adherent or not	not	some adherent	not.
Colour of testa	black (bl)	black (bl)	black (bl)
Size	med. to small	medium	medium (18 small 1 large, 5 medium to large)
Surface	smooth (s)	smooth (s)	smooth
Fuzz	present at apex presence at base variable	medium quantity at both ends and some over seed	present at both ends (1 at apex only) The quantity at basal end variable.
Fuzz colour	brown grey (br gr)	brown some-mixed with green (br gr)	brown (16 brown grey, 8 brown mixed with green)

The first generation plants were uniform: open in habit coming to maturing earlier than the Buck parent, but not so early as the Sea Island. They are vigorous in growth and possessed good resistance against anthracnose. The stems of all the plants were of a reddish purple—thus resembling closely the male parent, and their leaves were of a uniform reddish green—being intermediate in colour between the green of the female parent and the purplish red of the male parent. Their lints with one exception were long and were on the whole of good strength, while ninety-eight lints were silky like the Sea Island and five coarse like the Buck parent.

It was not possible owing to want of time and readily available land to continue investigations into very large numbers of cottons and therefore it was necessary after the examination of these first generation hybrids to decide what course should best be pursued. It was decided to select those that appeared to promise to suit the peculiar conditions of the colony and to keep careful records of some of their characteristics. Four of the most suitable of F1 were selected and 100 seeds of each were sown. The field characters of these four varieties were as follows :—

TABLE 1A.—Field Characters of Four Selected Generations F 1 Plants.

Plant.	Habit of growth.	Height, feet.	Maturity.	Disease resistance.	Stem colour.	Leaf.						Flower.									Fruit.		Remarks
						Petiole colour.	Blade colour.	Vein colour.	Stipules, hairy or not.	Shape of blade.	Blade, hairy or glabrous.	Bracts, size.	Flower, size.	Calyx teeth, size.	Calyx, thickness.	Corolla, colour.	Corolla, spot.	Stamen filaments, length.	Column, length.	Anthers, colour.	Bolls, shape.	Bolls, distribution.	
Parent. Sea Island (female) ...	d	5	e	p	gr	gr	gr	gr	not	3-5 partate	h	med	med	l	med	l y	med. light to deep red	s	l	o	l p a	r	
Parent. Buck (male)	o	10-12	l	g	p	p	pr	dr	h	3-5 partate	h	l	l	s	thin	d y	absent	l	l	d y	l p r	irr	
8	o	7	int.	g	p	dr	gr pr	r	h	3-5 partate	h	l	l	s	thin	l y	med. pale red	l	l	d y	l p a	r	
10	o	8	int.	g	p	dr	gr pr	r	h	3-5 partate	h	l	l	s	thin	y	med. pale red	l	l	d y	l p a	r	
59	o	7	int.	g	p	dr	gr pr	r	h	3-5 partate	h	l	l	s	thin	y	med. pale red	l	l	d y	l p a	r	A vigorous plant
103	o	9	int.	g	p	dr	gr pr	r	h	3-5 partate	h	l	l	s	thin	y	med. pale red	l	l	d y	l p a	r	A vigorous, well-shaped plant

For interpretation of abreviations, refer to previous descriptions.

TABLE I B.—Lint and Seed Characters of Four Selected Generations F 1. Plants.

	Weight of seed cotton per plant, lb.	Lint characters.											Seed characters.						Remarks.
		Proportion of lint to seed, per cent.	Weight lint per plant, lb.	Proportion of weak fibre, per cent.	Maximum length, mm.	Average length, mm.	Regularity of distribution.	Regularity of length.	Density.	Colour.	Strength.	Silkiness	Lustre.	Adherent or not.	Colour of testa.	Size.	Surface smooth or not.	Fuzz.	Colour of fuzz.	
Parent. Sea Island, female.	...	54·2	...	...	42·0	39·3	good at tips	g	irr	wh	p	g	g	not	bl	med. to over	sm	present in quan'ty	br gy	
Parent. Buck, male	...	46·0	...	...	28·0	26 0	good	g	r	wh cr wh	g	p	f	some adh.	bl	med	sm	present both ends	br gy	
8	1·5	48·0	·72	36·4	39·0	36·5	good mainly at tips	g	f.r	wh	v g	g	g	not	bl	med	sm	present both ends	br	Fuzz tufts at basal end of seeds small
10	1·3	47·6	·62	41·3	41·0	36·0	good mainly at tips	g	f.r	wh	g	g	g	not	bl	med	sm	present both ends	br	Seeds very like S. I.
59	1·1	47·1	·51	35·2	29·5	37·1	good mainly at tips	v.g	r	wh	g	g	g	not	bl	med	sm	present both ends	br	Some seeds had lint that was somewhat harsh
103	1·7	46·7	·79	31·7	38·0	35·9	good mainly at tips	g	r	wh	f.g	f.g	g	not	bl	med	sm	present both ends	br	Very little fuzz.

For interpretation of abbreviations, refer to previous descriptions.

Their lint and seed characters are shown in the following table:—

It was now decided to reduce the number of characteristics recorded, and the results of the analysis of F 2 generation were as follows:—

TABLE IIA.—Field Characters of 274 Generation F 2 Plants.

Plant.	No of plants examined.	Habit of growth.	Maturity.	Disease resistance.	Stem colour.	Leaf.			Flower.							Fruit.
						Petiole colour.	Blade colour.	Vein colour.	Size.	Corolla colour.	Corolla spot.	Stamen filaments, length.	Anthers, colour.	Column, length.	Style, length.	Bolls, shape.
Progeny of H. 8	64	210 43 d	15 e 34 int 15 l	23 p 41 g	17 p 34 d 13 gr	36 dr 14 r 14 gr	17 pr 44 int 12 gr	48 r 4 lr 12 gr	22 l 29 med 13 s	2 d y 56 y 6 p y	23 l 21 int 20 abs	33 l 26 med 5 s	500 14 y	46 l 18 s	48 l 16 s	55 l p a 9 l p r
Progeny of H. 10	66	300 36 d	26 e 35 int 5 l	21 p 45 g	19 p 32 dr 15 gr	26 dr 25 r 15 gr	11 pr 36 int 19 gr	41 r 12 lr 13 gr	26 l 34 med 6 s	1 d y 46 y 19 p y	24 l 28 int 14 abs	28 l 35 med 3 s	480 18 y	51 l 15 s	45 l 21 s	13 l p a 2 l p v remainder unrecorded
Progeny of H. 59	68	620 6 d	14 e 43 int 11 l	19 p 49 g	28 p 20 dr 20 gr	15 dr 34 r 19 gr	18 pr 31 int 19 gr	43 r 6 lr 19 gr	50 l 7 med 11 s	2 d y 57 y 9 p y	26 l 25 int 17 abs	31 l 35 med 2 s	580 10 y	53 l 15 s	42 l 26 s	unrecorded
Progeny of H. 103	76	690 7 d	12 e 42 int 22 l	20 p 56 g	24 p 33 dr 19 gr	11 dr 44 r 21 gr	16 pr 33 int 27 gr	47 r 14 lr 15 gr	38 l 24 med 14 s	1 d y 62 y 13 p y	36 l 16 int 24 abs	27 l 46 med 3 s	640 12 y	47 l 29 s	46 l 30 s	unrecorded
Total	274	1,820 92 d	71 e 150 int 53 l	83 p 191 g	88 p 119 dr 67 gr	88 dr 117 r 69 gr	62 pr 144 int 77 gr	179 r 36 lr 59 gr	136 l 94 med 44 s	6 d y 221 y 47 p y	109 l 90 int 75 abs	119 l 142 med 13 s	2,200 54 y	197 l 77 s	181 l 93 s	68 l p a 11 l p r

TABLE II B.—Lint and Seed Characters of 274 Generation F 2 Plants.

Plant.	Lint Characters.								Seed Characters.							
	Maximum length.	Average length	Regularity of		Colour.	Strength.	Lustre.	Silkiness.	Size.	Shape.		Fuzz.			Testa.	
			Distribution.	Length.						General.	Stalk or not.	Present or not.	Where situated.	Colour.	Smooth or not.	Colour.
Progeny of H 8 ...	46 l 18 s	46 l 18 s	64 reg	55 reg 9 irreg	64 wh	18 st 46 w	20 g 44 f	47 s 17 c	11 l 41 med 12 s	54 med 8 long 2 angular	64 s	64 p	57 both ends 7 apex only	52 br 2 gy br 10 gr	59 s 5 not	64 bl
Progeny of H 10 ...	50 l 16 s	50 l 16 s	66 reg	62 reg 4 irreg	66 wh	17 st 49 w	27 g 39 f	54 s 12 c	5 l 43 med 18 s	57 med 5 long 3 round 1 angular	66 s	66 p	56 both ends 10 apex only	65 br 1 gr	66 s	66 bl
Progeny of H 59...	41 l 27 s	41 l 27 s	68 reg	65 reg 3 irreg	68 wh	26 st 42 w	24 g 44 f	46 s 22 c	1 l 46 med 21 s	58 med 5 round 4 long 1 angular	68 s	68 p	61 both ends 7 apex only	66 br 2 gr	68 s	68 bl
Progeny of H 103	59 l 17 s	59 l 17 s	74 reg 2 irreg	70 reg 6 irreg	76 wh	18 st 58 w	27 g 49 f	56 s 20 c	2 l 59 med 15 s	67 med 5 long 4 angular	76 s	76 p	75 both ends 1 apex only	71 br 5 gr	76 s	76 bl
Total ...	196 l 78 s	196 l 78 s	272 reg 2 irreg	252 reg 22 irreg	274 wh	79 st 195 w	98 g 176 f	203 s 176 c	19 l 189 med 66 s	236 med 22 8 angular 5 round	274 s	274 p	249 both ends 25 apex only	254 br 2 gy br 18 gr	269 s 5 not	274 bl

TABLE III.A.—Field Characters of Seven Selected Generation F 2 Plants.

Plant.	Habit of growth.	Maturity.	Disease resistance.	Stem colour.	Leaf.			Flower.							Fruit.	Remarks.
					Petiole colour.	Blade colour.	Vein colour.	Size.	Corolla colour.	Corolla spot.	Stamen filaments, length.	Anthers, colour.	Column, length.	Style, length.	Bolls, shape.	
10·13	o	e	g	p	p	gr tinged with r	r	med	y	int light r	med	o	s	l	l.p.s	
10·21	o	e	g	dr	dr	gr tinged with r	r	med	y	s pale r.	l	o	l	l	unrecorded	
59·33	o	e	g	p	p	gr. r	r	l	y	absent	l	o	l	l	„	
59·59	o	e	g	r	r	gr tipped with r	r	l	y	l. r	l	o	l	l	„	
59·63	o	int	g	r	r	gr tinged with r	r. gr	l	y	int r	l	o	l	s	„	
59·66	o	e	g	gr.r	gr.r	gr	r. gr	s	y	s. r	s	o	s	s	„	Very like Sea Island plant.
103·34	o	e	g	gr.r	gr.r	gr	gr	l	y	l. r	l	y	l	s	„	

From these 271 plants of F2, seven were selected possessing characters of likely economic importance. The yields of seed cotton per plant, the length and strength of the cotton, and freedom from disease, were characters on which the greatest stress had to be laid, and as much as one would have liked to have continued a large number of the F2 generation, growing only a few plants of each, it was decided that the conditions under which the cotton experiments were being conducted would not allow of such a procedure. The characters of the seven selected cottons were as follows:

TABLE III B.--Lint and Seed Characters of Seven Selected Generation F 2 Plants.

Plant.	Lint characters.								Seed characters.								Remarks.
	Weight of seed cotton per plant.	Maximum length, mm.	Average length, mm.	Regularity of		Colour.	Strength.	Lustre.	Silkiness.	Size.	Shape.		Fuzz.			Testa.		
				Distribution.	Length.						General.	Stalk or not.	Present or not.	Where situated.	Colour.	Smooth or not.	Colour.	
10·13	1·25	36	31	reg	reg	wh	fair	g	s	med	med	s	p	at both ends little at base	br	s	bl	
10·21	1·75	32	30	reg	reg	wh	fair	g	fairly s	med	med	s	p	at both ends	br	s	bl	Lint short
59·33	1·1	27	25	reg	reg	wh	g	fair	c	med	med	s	p	at both ends	br	s	bl	Lint short and coarse
59·59	1·0	35	31	reg	reg	wh	g	fair	c	med to small	med somewhat angular	s	p	at apex only	br	s	bl	
59·63	1·4	33	28	reg	reg	wh	g	fair to good	s	med to small	med	s	p	at both ends	br	s	bl	
59·66	1·0	49	44	reg	reg	wh	fair	g	s	med	med	s	p	at both ends	br	s	bl	Long lint. A very fair Sea Island type
103·34	1·2	31	27	reg	reg	wh	g	fair	harsh	med	med	s	p	at both ends	br	s	bl	Density of lint, good

From these seven plants, 450 were planted out for generation F 3, and records were kept of 436 of these, the remaining fourteen dying before they reached maturity.

The details of the records of the field characters are shown in the following table :

TABLE IVA.—Field Characters of 436 Generation F 3 Plants.

Plant.	No. of plants examined.	Habit of growth.	Maturity.	Disease resistance.	Stem colour.	Leaf.				Flower.						
						Petiole colour.	Blade colour.	Vein colour.	Size.	Corolla colour.	Corolla spot.	Stamen filaments, length.	Anthers, colour.	Column, length.	Style, length.	
Progeny of 10·13 ...	82	60 o 22 d	23 e 46 int 13 l	71 g 11 p	9 p 49 r 24 gr	9 d r 49 r 24 gr	58 gr r	58 r 24 gr	7 l 50 med 25 s	82 y	18 l 44 med 20 abs	55 l 17 med 10 s	80 o 2 y	5 med 77 s	76 l 6 s	
Progeny of 10·21 ...	75	57 o 18 d	23 e 24 int 28 l	57 g 18 p	11 p 43 r 21 gr	11 d r 43 r 21 gr	54 gr r 21 gr	54 r 21 gr	2 l 18 med 55 s	72 y 3 py	14 l 44 med 17 abs	55 l 12 med 8 s	73 o 2 y	8 l 30 med 37 s	55 l 20 s	
Progeny of 59·33* ...	36	36 o	7 e 11 int 16 l	26 g 10 p	36 a r	36 r	36 gr r	36 r	4 l 18 med 14 s	36 y	6 s 30 abs	28 l 3 med 5 s	36 o	1 l 11 med 24 s	35 l 1 med	

* Uniform group of plants, very like Buck but of lighter stem and leaf colour.

TABLE IVA.—FIELD CHARACTERS OF 436 GENERATION F 3 PLANTS.—(*Concluded.*)

Plant.	No. of Plants Examined.	Habit of growth.	Maturity.	Disease resistance.	Stem colour.	Leaf.			Flower.						
						Petiole colour.	Blade colour.	Vein colour.	Size.	Corolla colour.	Corolla spot.	Stamen filaments length.	Anthers, colour.	Column, length.	Style, length.
Progeny of 59·59 ...	77	76 o 1 d	11 int 66 l	64 g 13 p	14 p 46 r 17 gr	14 d r 46 r 17 gr	59 gr r 18 gr	60 r 17 gr	54 l 23 s	76 y 1 p y	9 l 51 med 17 abs	54 l 23 s	71 o 3 y	53 l 24 s	60 l 17 s
Progeny of 59 63 10 ...	77	64 o 13 d	16 e 56 int 5 l	63 g 14 p	7 d r 53 r 15 gr	7 d r 53 r 15 gr	62 gr r 15 gr	62 gr r 15 gr	50 med 27 s	1 d y 75 y 1 p y	9 l 45 med 28 abs	60 l 17 s	67 o 1 y	52 l 25 s	6 l 71 s
Progeny of 59·66 * ..	49	5 o 44 d	49 e	35 g 14 p	6 r 43 gr	6 d r 43 gr	6 gr r 43 gr	6 r 43 gr	2 l 12 med 35 s	49 y	27 l 22 med	15 l 13 med 21 s	49 o	2 l 3 med 44 s	49 l
Progeny of 103·34 †..	40	40 o	10 e 17 int 13 l	29 g 11 p	8 r 32 gr	8 r 32 gr	8 gr r 32 gr	8 gr r 32 gr	9 med 31 s	35 y 5 p y	15 l 23 med 2 abs	26 l 6 med 8 s	9 o 31 y	2 l 5 med 33 s	11 l 7 med 22 s

*Uniform group of plants, very like Sea Island.

†Uniform group of plants.

TABLE IVB.—Lint and Seed Characters of 436 Generation F 3 Plants.

Plant.	Lint Characters.								Seed Characters.								
			Regularity of							Shape.		Fuzz.				Testa.	
	Maximum length.	Average length.	Distribution.	Length.	Colour.	Strength.	Lustre.	Silkiness.	Size.	General.	Stalk or not.	Present or not.	Where situated.	Colour.		Smooth or not.	Colour.
Progeny of 10·13	81 l 1 s	79 l 3 s	81 reg 1 irreg	81 reg 1 irreg	82 wh	38 st 44 w	82 g	66 s 16 c	4 l 65 med 13 s	82 med	78 s 4 not	82 p	82 both ends	43 br 23 gy br 16 gr		77 s 5 not	82 bl
Progeny of 10·21	46 l 29 s	46 l 29 s	74 reg 1 irreg	72 reg 3 irreg	75 wh	26 st 49 w	59 g 16 p	24 s 34 h 17 c	1 l 58 med 16 s	74 med 1 round	70 s 5 not	75 p	1 apex only 74 both ends	42 br 17 gy br 16 gr		71 s 4 not	75 bl
Progeny of 59·33*	3 l 33 s	3 l 33 s	36 reg	36 reg	36 wh	16 st 20 w	36 g	26 s 10 h	4 l 29 med 3 s	35 med 1 l	36 s	36 p	36 both ends	12 br 19 gy br 5 gy gr		35 s 1 not	36 bl
Progeny of 59·59	9 l 68 s	5 l 72 s	77 reg	74 reg 3 irreg	77 wh	47 st 30 w	52 g 25 f	28 s 25 h 21 c	10 l 60 med 7 s	71 med 4 round 2 long	75 s 2 not	77 p	77 both ends	41 br 22 gy br 11 gy gr 4 gr		73 s 4 not	77 bl
Progeny of 59·63	61 l 16 s	63 l 14 s	70 reg 7 irreg	77 irreg	77 wh	69 st 8 w	77 g	74 s 3 h	1 l 72 med 4 s	76 med 1 angular	77 s	77 p	76 both ends 1 whole surface	16 br 61 gy br 1 gr		71 s 6 not	77 bl
Progeny of 59·66	49 l	49 l	42 reg 7 irreg	48 reg 1 irreg	49 wh	27 st 22 w	49 g	45 s 4 h	1 l 35 med 13 s	46 med 3 angular	49 s	49 p	49 both ends	4 br 26 gy br 9 gy gr 10 gr		49 s	49 bl
Progeny of 103·34	5 l 35 s	5 l 35 s	37 reg 3 irreg	39 reg 1 irreg	40 wh	33 st 7 w	38 g 2 f	21 s 15 h 4 c	27 med 13 s	37 med 2 l 1 angular	40 s	40 p	40 both ends	13 br 14 gy br 1 gy gr 2 gr		38 s 2 not	40 bl

*Lint longer than Buck.

The seed and lint characters are given in the following table :—

These tables are of considerable interest, but we refrain from discussing them in detail as it seems to us to be desirable that data regarding a further generation should be available before any attempt is made to do so. The records available are not in sufficient quantity for a discussion on a possible gametic constitution of the particular plants originally selected for these experiments, as it has only been possible to carry on experiments with but a few plants out of each generation. However, there are sufficient data available to indicate that some strains of Sea Island and Buck cottons are pure in respect to certain of their characters, even though they may be impure to others. The tracing of these characters through several generations is not without interest, especially as these records form the first attempt in the West Indian colonies to follow several characteristics of the cotton plant in continued experimental culture through three generations along strictly scientific lines.

From the numerous hybrids that have been grown it would appear that it has been possible to select even in three generations cottons that seem to be practically pure to type. Variety 59.66 which is an extracted Sea Island cotton is of considerable interest. It is a plant which grows vigorously on heavy clay land and under meteorogical conditions where the ordinary commercial strains of Sea Island cotton practically refuse to grow. Variety 59.33 is likely to prove interesting also from the point of view of short staple cotton, especially as a certain number of the plants mature comparatively early.

Further selections have been made for continued experiments, and it is hoped, if these selections prove to be pure in regard to the characteristics of economic importance, to ascertain their yield per acre and their value on the market.

A point of some importance that has been observed in these experiments is that those cottons that have pure green leaf blades and green stems have matured earlier than those which were red to purple in colour.

Trials with Indigenous Cottons.

Trials have also been made with indigenous cottons from the Rupununi district of the Colony These cottons were collected from lands contiguous to the Brazilian boundary of the Colony and after they had been grown experimentally at the Botanic Gardens, Georgetown, their lints were sent to the Director of the Imperial Institute for examination and report.

The names of the cotton were as follows : Kineabu, Awinteardа, Wisadie, Bisa Tail, and Purume—being Brazilian types of cotton, and Suwardi which resembles somewhat in its habit of growth Peruvian and in the characters of its lint 'improved' American. The general report on the samples of cotton sent to the Imperial Institute indicated that they compared favourably with standard specimens of similar varieties and that it was probable that the Suwardi cotton would be in greater demand in the English market than the rougher Brazilian types.

The cultivation of these varieties is being continued, and the purity of their gametic composition has been and is being tested.

The Suwardi has been hybridized with Buck, improved Sea Island, and with Kineabu.

The results of the crosses of 1911-12 between these varieties have been as follows :—

Suwardi × Kineabu	13 crosses	103 seeds.
Suwardi × Buck	6 crosses	130 seeds.
Suwardi × 59.66.8 Sea Island	7 crosses	105 seeds.

In every case this year, the Suwardi was used as the female parent, as considerable difficulty had been experienced in former years when attempts were made to use this variety as the male parent.

AGRICULTURAL EDUCATION.

AGRICULTURAL EDUCATION IN GRENADA WITH SPECIAL REFERENCE TO THE BOYS' SECONDARY SCHOOL.

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Agricultural education with its many varied aspects of activity has received very thorough consideration on the part of the West Indian authorities during the last decade of years, and excellent work and example have been set in this direction by the West Indian Imperial Department of Agriculture. However, much yet remains to be done by both individuals and communities alike. I do not feel the need of apologising for making a few general introductory remarks on this vexed question for, unquestionably, the subject is so interwoven with the prosperity or decline of the West Indian Colonies that every opportunity should be given for its thorough consideration. It may be said by certain critics that a discussion at a conference is never productive of good results, but these good people overlook the fact that a great stimulus is exerted through these discussions. Persons labouring under common difficulties and desiring the same ends derive great encouragement from this interchange of views and notes, and, however stale a question may be, it can always be made presentable when clothed in a different garment. On these conditions I now submit my contribution.

Many attempts have been made in the immediate past to introduce rural teaching into the Grenada primary schools

but on the whole these efforts have resulted in an almost complete failure. A full rendering of these efforts, historically, constitutes a sad story. Up to the present time, no stable effort has ever been made for the establishing of a sound system of rural or agricultural education, although a good sum of money has been spent in giving short courses of lectures to teachers, in laying out school gardens, and in paying bonuses to teachers. A movement is now on foot to equip a good secondary school for the needs of the island, and it is the main purport of this paper to show how this school will be related to the island in general, and to the agricultural community in particular. In doing this, I feel justified in reviewing the past efforts already referred to, to show how and why they have failed, and to suggest a more comprehensive and stable scheme for supplying the educational needs of the Colony for the present and for the coming generations.

These attempts to supply the primary school children of Grenada with this training in the rural education were mostly made within the first few years of the last decade, but I am grieved to say that during the last few years, activities in this respect have been almost dormant. Mr. Harbin, the Inspector of Primary Schools, has laboured under great difficulties in this respect and greatly deplores this apathy on the part of the teachers to the need of their environment. In the first place the teachers themselves must be given a sound and sympathetic knowledge of rural necessities and teachings. Three series of lectures of a public character have been given under the auspices of the West Indian Imperial Department of Agriculture, two series in 1900 and the other in 1903. As a result of the examinations held at the end of each course, a large number of teachers were certified as first grade teachers of agricultural science—undoubtedly a hasty thing to do considering the short time these teachers were under tuition, and certainly proved by the subsequent turn of events. All the lectures were undoubtedly productive of good results immediately but were meant for temporary reasons, so that the ultimate good was made subsidiary to the immediate benefits. These courses have never been properly followed up, and this explains largely the subsequent decline in the interest for rural teachings. Spasmodic efforts, in educational matters particularly, are never productive of good results.

During 1903 and 1904 rural science, we are told, was satisfactorily taught in all the primary schools, but the enthusiasm soon began to wane. We find a motion brought forward by the Hon. D. S. De Freitas that curtailment of grants be made for schools that did not make use of the plots they possessed. Probably the most teaching of nature study was done in 1905, but even then we find the teachers beginning to complain of the extra work involved with no corresponding increase of pay. However, bonuses were paid. No new plots or school gardens were made during the year and it was suggested that half the time in the primary schools be compulsorily devoted to the teaching of agricultural and technical pursuits. Towards 1907, a general apathy set in upon the teachers as a whole, and the school plots which were previously the centre of much activity now

fell into disuse and presented the outlook effectively described at a previous conference by a Jamaican delegate regarding the decline of the school gardens there: 'Where but a few torn shrubs the place disclosed.'

Many of the members of the Board of Primary Education felt most keenly this carelessness on the part of the teachers but in the face of the difficulties of the time no remedy could be procured. It was hoped that the new code then in the making would improve matters. In the records, it is stated: 'the conditions disclosed in 1906 was the inevitable result of the uncertainty which clouded everything connected with Primary Education.' Since that time, no advancement has been made in this respect and the gardens have been literally abandoned. Some teachers still continue to teach the 'theory of agriculture' but such teachings can never be productive of any practical results. It will only make pupils shirk more and more their duty to the soil and its production. The Inspector of Primary Schools has kindly placed much useful information at my disposal and which I have carefully perused.

The great educational need of the island at the present time is the institution of a thoroughly organized correlation of agricultural educational activities throughout the whole island, primary, secondary and technical. The primary schools should be the basis on which the subsequent training is built, and should therefore aim primarily at drawing the boy to the love of nature and agricultural pursuits. The failure of the primary schools in this respect is probably due to a variety of causes, mainly among which may be mentioned the absence of the real scientific basis in their teaching, their lack of sympathy owing to their limited knowledge of agricultural science, and the absence of a system of training in the theory and practice of education in the primary educational system of the Colony.

What is education, and why should education along scientific lines be now so generally insisted upon, by all leading educationists of the present day? This is a vexed question and has engaged the minds of all lovers of education from time immemorial. The stages in the evolution of the ideas in education, the ever-changing 'truths' and precepts of our educational philosophers, are indeed a complicated whole, and make it hard for one with an unbiased mind to strike a harmonious course through such conflicting maxims and precepts. The gradual introduction of the modern or scientific method into our schools marks the trend of the age for utility. This is due to the fact that whichever branch of human activity we consider, whether they deal with the preservation of mankind as a unit or a collection of units, or the training of them for the part they should play in life as citizens, knowledge of science, and I may even say natural science, is of more value than any other knowledge. The natural sciences deal with the meaning of things and not the meaning of words, and therefore, remain superior in all respects to languages and mathematics as educational material. In fact, I have heard it said time and again by one of the leading educationists of the University of Oxford that he considered mathematical studies

as one of the worst trainings for the mind. Science trains the mind, cultivates the judgment, and above all things it necessitates method in all its branches of study. Hence the reason why the study of some branch of natural science is now considered so essential a part of a 'liberal education' of the present day. The teaching of science in schools, however, is often utterly spoiled by not adopting the proper laboratory method, by merely memorising facts, while memorising facts out of a science text-book is of far less use than memorising tables out of grammar and vocabulary books. A training along scientific lines is highly desirable in all branches of activity, for it makes the senses to observe accurately and the mind to express explicity, and it enables its pursuers to practise orderliness in thinking through arranging facts in groups by collecting and comparing, and supplying 'the rational explanation of phenomena', so very important from the standpoint of agricultural science and practice. Under these conditions every boy that passes through a secondary school under my care will go through a systematic course of elementary science whatever his future vocation may be.

A great deal is being said in all countries concerning the apathy of the agriculturists themselves towards the introduction of agricultural study into our schools. This disinterestedness is not without its justifiable cause. Every practical agriculculturist knows that the teaching of agriculture in our schools, and particularly so in the primary schools, is impossible. The word Agriculture should be altogether kept outside the scope of primary school curriculum and its use in this connexion is inexcusably wrong. It is not agriculture and cannot be so. It is only some of the most elementary principles on which the great art and science of agriculture is founded that can be taught in the elementary school. Call it 'elementary science', or 'object lesson', or 'nature study'—the term now generally used by the English educational authorities as the result of dire experience—but never call it Agriculture. This has greatly alienated the steady sympathy of the rural population in England; but now things look brighter, owing to the authorities referring merely to the teaching of Nature Study, or at the most Elementary Science, and what is true of the farmers of England is equally true of the planters of the West Indies. Confine the children of the lower standards to the studying of a few of the simple facts of nature that surround them and thus give them an intelligent view of nature's ways. In later stages, or the higher standards, some proper elementary science can be taught, with as much as possible of the out-door work. This represents all that can be done in a primary school as regards rural teaching, and at a glance it can be seen that the word Agriculture is far from being applicable to it.

It is the duty of every teacher to inculcate into every boy the habit of enquiry regarding nature as manifested in animal and vegetable life; and particularly so, things useful or harmful to man. This the teacher cannot possibly be expected to do unless he has himself been infused with a love of nature, and therefore, lacks that sympathy with the subject—one of the great essentials in any good teacher. He should also be train-

ed in the art and theory of teaching, for in no subject can the beneficial results of good teaching be more hopelessly lost than in the teaching of science in untrained and unpractical hands. In Grenada, hardly any of the teachers are in any way trained —a fact that accounts greatly for the present unsatisfactory state of its rural teachings.

The Grenada Grammar School was opened in 1885, but up to the present time no attempt has ever been made to teach in it any form of scientific or agricultural studies, the tuition being purely classical, mathematical, and a few other minor subjects. The management of the school was taken over by the Government Authority by the Secondary Education Ordinance of 1909. It is now designated 'The Boys' Secondary School' and is a distinct Government Department. On the whole, it has been thoroughly reorganized with the main intention of making agricultural scientific studies occupy a most prominent position in the curriculum. It was reopened at the beginning of last term in new buildings and owing to the influx of the new pupils—the number having already been more than doubled since I have been in charge—the present accommodation of class-rooms has been taken up and a need for an enlargement of class-rooms and additional staff felt. The Head Master's class-rooms have been fitted up with chemical and biological benches, scientific apparatus and appliances, and proper arrangements made for the teaching of agricultural and pure sciences along approved lines of instruction for the needs of the Colony.

There is a wholsome need at the present time of bringing the teachings of the primary schools into a more direct connexion with that of the secondary school. It is hoped that some solution in this respect will soon be reached. When the laboratory equipment is properly made, courses of instruction, whether in the form of Saturday courses or vacation courses, can be arranged for the teachers in the fundamental principles of agriculture and science in general, at the same time giving them a few lessons on the theory of teaching with special reference to the teaching of science and other modern subjects. Under these conditions, and under these conditions only, can the status and nature of the teaching be raised to that standard desirable in such an agricultural community as inhabits Grenada.

I realize the part that should be played in this respect by the Boys' Secondary School—the centre of a real system of agricultural education for the Colony. The development of this agricultural education at the Boys' Secondary School does not mean at all that it shall be developed at the expense of other subjects—classical or mathematical. It merely means the development of the agricultural sciences along with the others, at the same time correlating them as much as possible. Steps are undertaken at the present time to have a Mathematical Master added to the staff, for development of all subjects is necessary in order that the youths of the island may have an equal chance along the line of study they are individually and naturally bent.

During the last term the boys were arranged into three Forms and great difficulties were experienced in this respect owing to the varied attainments of the different boys, and particularly so the higher boys. The average age for the pupils of Form III is 16, for Form II 14 and for Form I 13. Thus it can be seen that the pupils' ages on the whole are above the ages of boys in a general public school. None of the boys have ever been taught any science, so that there is a kenness and enthusiasm existing for its study, which it is hoped will be well maintained. It is not possible for all the boys in any Form to be engaged in practical experimental work concurrently, owing to our laboratory not yet being fully equipped. The working accommodation on the chemical benches is for eight, but in elementary work the pupils will be arranged in couples so that almost a whole Form may work at the same time. These conditions will suffice for some time, provided a fuller equipment of scientific instruments be obtained, for which estimates have already been submitted. Up to the present science instruction has been given to the two upper Forms, and this for three hours a week each. This was confined mainly to a consideration of the fundamental measurements and principles of experimental science, a thorough grounding in which is absolutely essential to an understanding of any branch of pure or applied science. As far as can be seen, the instruction is based on chemical and physical lines, but courses of instruction in the principles of biological science will be initiated next term. In this respect, I may mention that I consider drawing as an art that requires special cultivation in any agricultural institution. It is wonderful how this art is so often disregarded in our schools, in many cases the pupils being unable to sketch the simplest objects of nature. In a scientific training, it is particularly useful, for it trains the eye as well as the hand. With the advent of more natural science teachings into our schools—whether biological, chemical or geological—this art must gain more prominence and one hour a week at least will be devoted to its cultivation by each Form throughout the school. A great essential towards the promotion of a healthy study of scientific pursuits is the institution of a School Museum, a place utilized for the preservation of those objects which best illustrate the phenomena of nature and the works of man and the employment of these for the increase of knowledge and for the culture and enlightenment of the people. I hope to organize one in connexion with our school in the immediate future, and it is hoped that all the collections made—and in this respect the school pupils will be encouraged as much as possible to collect specimens of animate and inanimate objects—will be duly labelled and a proper classification made. All things of this kind will arouse the boys' interest and even make them unconsciously passionate of nature's own ways.

The agricultural teaching of this school will not be placed on a sure foundation until some experimental ground is properly supplied. The Superintendent of Agriculture in his scheme for making the Botanical Gardens more useful economically has kindly placed at the disposal of the school a plot of land in the Gardens, about $\frac{1}{4}$-acre in area if

necessary. This plot will be laid out into sub-plots suitable for the cultivation of agricultural produce and for chemical or botanical purposes, such as manurial experiments and a few experiments following Mendelian principles. The gardens are situated within a fairly easy access of the school. Each agricultural pupil will be put in charge of each sub-plot in turn and made entirely responsible for its proper management. A pupil really keen on agricultural pursuits shall in this way be soon singled out and trained along desirable lines. Plots of this kind make most useful adjuncts to agricultural scientific schools and a full and proper use will be made of ours.

We have yet no definite scheme propounded for agricultural scholarships, apart from the usual Minor Government Scholarships open to all boys alike. A scheme suggesting that the Local District Boards may each offer a Bursarship of £25 a year, free tuition being allowed by the Government Authorities, is now under consideration by each individual Board, and it is hoped that this or some other more suitable scheme will soon be put into operation. Undoubtedly many bright youths of an agricultural inclination are in need of assistance of this kind and something must be done for them.

So far, I have confined my remarks to discussing the relation of the school to the lower stages in the development of our agricultural teachings. There is another aspect of our school equally important and equally in need of every encouragement. It is the relation of the school to the purely agricultural work. The teaching of agriculture proper will only be attempted in school when specialization proceeds in the higher Forms. There is yet no definite scheme drawn up, but no boy shall be taught agriculture until he has been well initiated into the scientific principles on which it is based. To make the matter clear, let me say that it is almost useless to try to teach boys the nature of manures and their effects under diverse conditions. Similarly the teaching of plant pathology cannot be satisfactorily undertaken until the pupils possess a practical acquaintance with plant internal morphology and physiology. This has been the great fault of too many of our agricultural schools and colleges in the past, at home and abroad alike, and explains to a great extent why so many of our practical farmers look with suspicion at our agricultural scientific teachings. I have spent almost the whole of my life among practical farmers and have had ample opportunities of knowing what their feelings on this question really are. It is no more justifiable to designate a man loaded with all agricultural scientific terms possible 'a scientific agriculturist' than it is to label a man carrying a box of surgical instruments a surgeon. In both cases they are means to an end and in idle or untrained hands are liable to produce serious consequences. The great need is to instil our boys with a love of nature. This can only be done along the proper experimental method. Inculcate them with the true meaning of experimental science and the great lessons it teaches, and then we shall have no cause of anxiety regarding the future of our agricultural education.

The school holds a close relation with the planter's life, and in this respect immediate steps of action are contemplated. The cadet system has been very well organized—all due thanks to the West Indian Imperial Department of Agriculture —throughout the British West Indies, and has already been put upon a sound basis. A scheme is now on foot to the same purpose in Grenada, and will, it can be justifiably said, supply a much desired want. The conditions of the cadetship have already been drawn up and at the present time are under discussion by the Government Authorities and the Board of Agriculture. One of the great questions that face the School Authorities of these islands is the vocational outlook of their pupils. Considering the fact that the West Indian Islands are practically entirely dependent upon their agricultural development, and that the realities of to-day are almost insignificant as compared with the possibilities of to-morrow, under proper attention, we can look for a part of the solution of this perplexing question to agricultural vocations. In Grenada, as elsewhere in these islands, we experience the same inherent aversion to any work connected with the soil. It is hoped, however, that by a steady system of organized teaching this distaste to manual labour will be overcome.

The details of the cadet scheme, as proposed by the Superintendent of Agriculture, are as follows :—

(1) Boys holding cadetships shall be known as Agricultural Department cadets in distinction from such Botanic Station cadets as may later be admitted.

(2) The number of cadets attached to the Agricultural Department shall be two.

(3) Agricultural Department cadets shall be appointed by the Governor from the Boys' Secondary School on the recommendations of the Superintendent of Agriculture and the Head Master of the Boys' Secondary School.

(4) Cadetships shall ordinarily be tenable for one year, but the term may be extended at the discretion of the Superintendent of Agriculture.

(5) A remuneration of £12 per annum and payable at the end of each quarter shall be granted by the Agricultural Department to each cadet.

(6) Boys shall attend such classes at the Boys' Secondary School as may be deemed advisable by the Head Master.

(7) Four months of the first year of cadetship shall be spent at the laboratory of the Agricultural Department and for the remainder of the year cadets shall be attached to the Botanic Gardens.

(8) Cadets shall attend the lectures and demonstrations given by the Agricultural Department in connexion with the preliminary examination of the Reading Courses of the Imperial Department and shall register for and take that examination.

(9) In the first year of cadetship, each cadet shall visit various plots under the direction of the Agricultural Department, and efforts will be made by the Department for all

cadets to get an insight into such experimental work as may be conducted by the Department.

It is hoped that in a few months' time this scheme will be in full working order having received all the necessary sanction.

This qualifying examination for overseerships is particularly practical in its demands and should be the means for many people other than cadets to make themselves conversant with West Indian agriculture, and should therefore receive every possible encouragement. Agricultural pupils of this school will be trained for it as far as circumstances will permit.

No efforts can be left unspared to elevate the condition of West Indian Agriculture. I speak most particularly of Grenada, whose condition in this respect is far from being satisfactory. Considering what Grenada can do in the matter of supplying herself with many of the products now imported from other countries, and improving her agriculture in general, it is a surprise that such a state of affairs has been allowed to exist so long. This importation of agricultural commodities, which can be produced by the island producers themselves, extends to the value of roughly £12,000 a year, as is clearly shown by the Superintendent of Agriculture in the economical section of his paper on the peasant problem. These imported commodities can equally well be produced at home. But some say that praedial larceny is too common to allow smaller investments. Grave rumours exist regarding the general participation in this custom, deterring small planters particularly from soil investment. In any case it is a question and complaint that should be thoroughly considered, for a peaceful working of small holding settlements is highly desirable for the successful regeneration of the rural cultivation. To show how this can be done would be to digress further from any subject, but sufficient has been said to show how I consider initiation should proceed. The *laissez faire* attitude of the past generation will not hold good for the present days of competition. We know of the spirit underlying the intensive system of English agriculture and the *petite culture* system of French husbandry, a system that has almost metamorphosed the surface of a whole country and emerged a nation safely from her financial perplexities. This is the spirit that should be infused into the West Indian planter and peasant. Modern methods must be adopted along scientific lines, scientific in the real sense of the word, and then humanity will reap heavily of the riches that Nature has so lavishly bestowed on our beautiful and productive island homes.

THE NEED FOR HIGHER AGRICULTURAL EDUCATION IN THE WEST INDIES.

BY DR. A. FREDHOLM,

Trinidad.

At the Annual Conference of the Inter-Colonial Agricultural Union held at Bloemfontein on 25th and 26th November 1908, the President, Mr. G. G. Lee of Cape Town, said in his opening address: 'What could be made more interesting to a boy or a girl than a few simple truths as to the wonders of plant growth, and the marvellous miracles which are enacted day by day in the soil at their feet. Yet these find no place in a modern education. And thus it goes on year after year, while the country is crying aloud for men and women of brains and energy to develop its enormous possibilities, we are turning out generations with no knowledge of the elements upon which the whole future of the country depends. Therefore I maintain that this Union and every organization interested in agriculture in South Africa should look to this as one of the most important labours within the sphere of their influence. We must not begin by blaming anyone. We are as much to blame as anyone else. Our part is to help as far as possible in righting what I conceive to be a great wrong to the whole of our people, for this is a national question of the greatest importance.' These are strong words in an earnest plea for agricultural education and they are applicable not only to South Africa but to every country where agriculture is paramount and agricultural education neglected.

In the West Indies we seem now to be somewhat further advanced chan South Africa was in the year 1908. Most colonies have provided in their primary and secondary schools some instruction in agriculture and the sciences on which it is based. Nature studies have been introduced and school gardens established. These are steps in the right direction—but short steps by which we can never make much progress. The claim that by these means a love for nature and for agriculture is engendered in the young may be valid—but how do we foster it? Do we sow the seed, carefully tend the young plant and accord it such treatment that it brings forth an abundance of flowers and fruit and leaves as a rich harvest to garner? I fear that we do not. Let us examine the average career of a young man who, having finished his school education has succeeded in keeping alive an interest in agriculture and decides to follow that vocation. He secures a position as overseer on an estate. The work is arduous and the hours of duty long. While daylight lasts the field work claims his attention, and in the evening book-keeping occupies his time. Few and far between are the hours which can be devoted to study. There is no doubt that in course of time the young man will learn the routine of that branch of agriculture to which he has given his attention. He will soon be an expert in the management of labourers, will know the planting and harvest times and how to care for the growing crops. This stage reached and he

has become a practical planter. He can now follow in the footsteps of those who have preceded him. As long as familiar ground has to be traversed all is well, but if conditions change or unusual happenings occur, as soil exhaustion, plant epidemics or invasions by insect pests, then he is confronted with problems which he cannot solve. Not because he lacks the inherent ability to do so, but because he is untrained in his profession. I must state, and that most emphatically, that I do not decry the sterling qualities of our practical planters —far from it. They have unflinchingly faced many serious situations and manfully met many dangers and have overcome them—but at what cost?

The influence of science upon practical agriculture and the attitude of one towards the other are well expressed in a letter from Professor Huxley to Mr. J. Harrison read before the Easingwold Chamber of Agriculture in 1891: 'There are some general principles which apply to all technical training. The first of these, I think, is that practice is to be learnt only by practice. The farmer must be made by thorough farm work. I believe I might be able to give you a fair account of a bean plant, and of the manner and condition of its growth; but if I were to try to raise a crop of beans, your club would probable laugh consumedly at the result. Nevertheless, I believe, that your practical people would be all the better for the scientific knowledge which does not enable me to grow beans. It would keep you from attempting hopeless experiments, and would enable you to take advantage of the innumerable hints which Dame Nature gives to people who live in direct contact with things.'

If it is true that practice can only be acquired through practice, the assertion that familiarity with the sciences bearing on agriculture enables us to arrive quickly at results which otherwise could only be reached through laborious and expensive experiments is undeniable. The cost of experimental work is frequently so great that the planter is debarred from undertaking it. That research is recognized as absolutely necessary is demonstrated by the fact that Departments of Agriculture, Imperial as well as Colonial, have been established, in which scientific investigations and experimental work are conducted. Most valuable to the West Indies have been the labours of their departments. The various publications issued from these establishments record what they have accomplished and a comparison of these records with those of similar institutions in other parts of the world will convince us that our departments are second to none and that we are justified in pronouncing the dictum 'well done' when reviewing their works.

Neither the departments of agriculture nor the planters can be blamed for the crude manner in which agricultural operations are conducted in the West Indies and for the ignorance prevailing among all classes of practical agriculturists. Many reasons can be assigned for this backwardness, one, and probably the principal one being the absence of a body of trained men as proprietors and managers, and the lack of skilled labourers.

This has long been recognized, and frequent reference to the matter is found in the agricultural publications of the West Indies. In 1891 J. H. Hart, F.L.S., wrote: 'The agricultural wealth of a country depends entirely upon the knowledge, skill and thrift of the cultivator. Skill is of slow growth: the labourer acquires it by plodding application and by a close study of the duties of his vocation. The skill acquired by one generation is capable of being transmitted to another, and improved upon by each, as it passes from father to son, yet the agriculturist in the tropics often starts without the knowledge of a single one of those simple elementary scientific truths on which modern agricultural science is based, and the result is that he often remains in complete ignorance of them, depending even upon his hired labourer for the practice and experience of the industry in which he is engaged.

'Need exists for skilled labour of every kind, before a country is able to make much advance in methods of cultivation. To produce skilled labour we must have education of a proper kind. The native labourer here may not be the equal of his European confrere, but he is capable of acquiring a high degree of skill in all mechanical and industrial arts; but as long as he remains a mere human chattel, as the imported coolies and many others are, so long will the country fail to make progress in its methods of culture.

'It is important in the commencement to distinguish between the several classes who require education of the kind to which we have made reference.

'In a West Indian community the owners of property and large occupiers would constitute the first class. The overseers of estates and small holders would constitute a second class, and the labouring classes would constitute the third and lowest class.

'It is doubtful if the agricultural labourer can be reached by any other means than by primary education.'

In these few lines Mr. Hart has drawn what will readily be recognized as a true picture of agriculturists and agricultural knowledge in the West Indies, and he has also called attention to the only remedy—agricultural education. It and it alone can bring together the agricultural scientist and the practical planter and engender that confidence and co-operation so essential to success in this vocation which is the practical application of scientific truths. It is difficult for a planter who is untrained in science, ignorant of its methods and aims, generally even devoid of knowledge of the fundamental principles which form the basis for the professional practices, to understand the methods and aims of the highly trained scientist. It is not his fault—the opportunity has never been given him to learn agriculture in any other manner than through practice. Men so differently trained must view things from entirely different standpoints.

School gardens and agricultural instruction in elementary schools do good and should tend to produce a more intelligent class of agricultural labourers, but they are of small service to the future overseer, manager or proprietor. They require a

higher grade of agricultural education, such as is provided by agricultural schools and colleges. Such institutions are lacking in the West Indies, Attempts have been made from time to time in different colonies to provide agricultural education of a higher standard. The need has been felt. They have generally taken the form of apprenticeships, sometimes called cadetships, in the Departments or Botanic Stations; reading courses and lectures have been tried, but we cannot flatter ourselves that our endeavours in this direction have been successful. The reason for this is not difficult to find. The imparting of higher agricultural education has only been a secondary matter at those establishments where it has been undertaken—it has not been the result principally aimed at. All the resources of the institutions, all the energies of the staffs, have not been devoted to education. No trained teachers in agricultural science have been specially employed. In consequence the training has not been thorough and therefore it has failed to receive recognition. No trained agiculturists, as the term is accepted in other countries, have been turned out in the West Indies. The old precept 'whatever is worth doing is worth doing well' has not been followed.

We often hear it stated that the agricultural schools and colleges of the world are open to students from the West Indies and that they can study their profession abroad—in England, in Continental Europe, or in North America. In all these countries excellent schools and colleges are found, but they do not meet the requirements of the West Indies or any other tropical country. They are located in the temperate zone and to their students are imparted the practices and theories of agriculture evolved to suit conditions in that clime Although the fundamental principles underlying agriculture are and must be the same everywhere, the elaboration and application of these principles vary with different environments. A young man having studied agriculture abroad will become imbued with the practices of agriculture which he has seen successfully demonstrated, but which would be utterly impracticable in the tropics, and the pursuance of which would certainly result in failures. Conditions are so different that several years will elapse before the foreign-trained agriculturist can successfully make practical use of the theoretical knowledge which he has received. During this time much nicety of judgment must be exercised, some precepts modified, others eliminated and entirely new practical experiences acquired. In this matter I can speak from personal knowledge, as my training in scientific agriculture was received at one of the leading agricultural colleges of Continental Europe. Thorough as the training was, I have not yet practised my profession (and I have had the opportunity to do so in many parts of the world and under many conditions) in a place where I have not found it necessary to employ largely the processes of modification, elimination and amplification. I am certain that this statement will be endorsed by many other delegates to this Conference who have been trained in their callings abroad.

The agricultural profession is not the only one which is best learned where practised. In Health Progress and Administra-

tion in the West Indies, Sir Rubert Boyce, M.D., F.R.S., wrote: 'A feature in the islands which I visited, and I have reasons to believe a feature which is universal throughout the West Indies, which struck me with admiration, was the magnificent provision for the sick and infirm and mentally afflicted. Too much praise cannot be bestowed upon these admirable humane and civilizing institutions. My only lament was that our medical students in England do not come over and see these institutions, and spend some months studying the tropical aspect of medicine. I felt that it would be a revelation to them, and would be the first step towards making them what Mr. Chamberlain dreamt of, namely, medical men, not only of Great Britain, but of the vast British Empire, equally equipped to treat the sick in an English country village, or in some far remote, half-civilised and distant province of the great Empire.

'I fervently hope that the time will come when the medical student's training will not be deemed complete until he has gained a practical knowledge of the other diseases of our globe, in which the British have such large holding. In my opinion, the awakening and broadening of mind which such travelled students would obtain would be of far more practical use to them, and of a more stimulating nature, than a large proportion of the so-called scientific training, or rather smattering, which they receive in the botanic, zoological, and other laboratories in the present day university.' Here is given the opinion of one who was among the foremost authorities on tropical medicine. He emphasizes the value of studies pursued where the profession is to be practised. If such training is a desideratum in the medical man, how much more so must it not be in the agriculturist whose vocation is influenced by local conditions to a far greater extent? In the Government Handbook of Victoria we read: 'There are institutions in England which profess to give an agricultural education fitting young men for colonial life, but the training obtained under such circumstances must be very defective. The knowledge of colonial conditions must be wholly theoretical and the time spent in such institutions is likely to be almost entirely lost.'

Agricultural education is a technical education. Its requirements are lucidly set forth in a paper by Henry F. Moore on Agricultural and Technical Education in the Colonies, read before The Royal Colonial Institute on January 13, 1891 In the part 'What should Agricultural and Technical Education be?' he says: 'So far as Agricultural Education is concerned it must not be forgotten that farming itself consists of three branches. There are first of all the principles which underlie the art, which are variously termed, "science," "theory," and, by the late J. C. Morton, the "truth" of agriculture. This is the side which is too often looked upon as the whole subject of agricultural education; in reality it is but the beginning of the actual making of a successful farmer. The work of agriculture itself begins with actual practice on the farm, or, as it may be termed, the art of agriculture. In this the man is brought in direct contact, not so much with principles and ideas, as with something very rare, his own soil and his own

climate. He has to learn how to manage these and to apply any theory he may have acquired for his own practical advantage.

'It is here where for the first time he begins to prove his capability to attain success as a farmer. But outside the field or the byre—outside the ring fence of his farm—a very important portion of the work of a successful farmer has to be done He has to deal with men and things—with the world outside him; he has to buy and sell; he has his relations with his landlord, with the State, and with the trader. On all these matters which constitute the business of the farmer, his success or failure will very much depend.'

'Few vocations place man in as close contact with the 'outside,' with 'men and things,' as agriculture. He is daily associated with the physical and chemical forces of nature and their manifestations, with the plant and animal life surrounding him, with mechanical appliances of many kinds, with his fellow men and women in various ways, as employer of labour, as consumer and as producer. Varied indeed must be his training to fit him for the important rôle he is called upon to play in the economics and progress of the world. It was Leibig who wrote: 'Perfect agriculture is the true foundation of trade and industry—it is the foundation of riches of states.'

That the West Indies are well nigh exclusively dependent on agriculture no one can gainsay. Statistics from the various colonies show that 79 per cent. of their population are occupied with agricultural labours and that about 95 per cent. of their exports are agricultural products. About 15 per cent. of the revenue of the British West Indian Colonies is derived from agricultural sources. When so preponderating a percentage of a country's population is engaged in a certain pursuit and when that same pursuit furnishes its chief export and is the source of one of its principal revenues, it would seem but just that the most adequate opportunities to acquire thorough knowledge of all pertaining to that pursuit should be afforded, and it seems a lamentable shortsightedness not to provide them. The governments of the majority of civilized countries have realized this, and have established agricultural schools and colleges. What they have accomplished for their different countries is easily ascertained. Let us briefly review a few statements made by writers who have investigated this matter. The list of references would be too lengthy to give here but I am prepared to submit it to anyone desirous of going further into this matter and can vouch for the profitableness of consulting the various writers. I have endeavoured to quote only what I consider unbiased opinions.

From the British Empire: 'The nurseries of our imperial prosperity are to be found in our technical schools. Agricultural education is for our colonies what the mother's milk is for the infant.'

From Great Britain: 'Great Britain depends so largely on commerce and manufactures for its wealth that we have been slow to recognize the importance of its agricultural class.

Of late years a change for the better has taken place and agricultural schools and colleges have been founded. This recognition of the claims of agriculture can have only one effect—more wealth will flow from the true source of all wealth—the soil.'

From the Dominion of Canada: 'No education is so widespread and effective in its results for good as that imparted to our youths in the agricultural schools and colleges.'

From the German Empire: 'It is estimated that the capital invested in the technical education of our farmers has returned an interest of 250 per cent. annually for the past half century.'

From Wurtemberg, Germany: 'The small kingdom of Wurtemberg, of the German Empire, with a population of 2,000,000 living on an area of 7,531 square miles is probably the most complete example of the effect of agricultural education we possess. A contented, happy and prosperous people is the verdict of all who visit this fertile country . . . . . It is only fifty years since Wurtemburg had the reputation of being one of the poorest of the German provinces. Agriculture failed to provide a means of subsistence, mainly owing to a bad system of financial aid and the ignorance of peasants.'

From France: 'No nation can afford to neglect the technical education of its husbandmen.'

From Sweden: 'Among our national institutions of learning the magnificent agricultural colleges of Ultuna and Alnarp hold unchallenged the first place both as to efficiency of training and importance of work.'

From Denmark: 'The important influence technical education had on the material, social and economical development of the people was indicated in the case of Denmark, which had from being the poorest of European countries become one of the richest.'

From Norway: 'Uneducated and unskilled farmers waste national wealth; educated and skilled farmers make national wealth.'

From Holland: 'A trained class of agriculturists is a country's richest asset.'

From Russia: 'The agricultural colleges are the nurseries of Russia's greatness.

From Hungary: 'Hungary boasted of an agricultural college in the eighteenth century and may claim priority amongst the countries of the world in providing systematic agricultural education for her people. There are now four agricultural colleges with courses ranging from two to five years.'

From Italy: 'Agricultural education makes prosperous individuals, good citizens and mighty states.'

From Switzerland: 'In Switzerland there are sixteen agricultural schools with about 400 students.'

From the United States: 'There was a time when rich, virgin soil could readily be found and the farmer could flit to it

when the old homestead became unprofitable. To-day he adopts other methods. He studies his profession in the agricultural colleges or schools and by the aid of the training there received he rejuvenates the soil and raises such crops on the old lands as were never dreamed of by previous generations. . . . . The agricultural educational institutions richly deserve the fostering care accorded to them by the federal and state governments.'

From Mexico: 'To neglect the technical education of the farmer is a national crime.'

From Brazil: 'Agricultural education will in a few generations do more for the Republic than any other agency, educational or financial.'

With such evidences before us can we doubt the benefits which accrue from agricultural education? 'History is looking backward that we may intelligently look forward.' May we benefit by the retrospect!

In the United States aid in the form of land grants and special Federal and State appropriations are given to institutions teaching agriculture. Statistics for 1909 show that the aggregate value of the permanent funds and equipment of the land grant colleges and universities was estimated at $111,882,686·96. The income of these institutions exclusive of the funds received from the United States for agricultural experiment stations was $18,082,853·55; special appropriation for experiment stations was $1,180,780·09. The value of the additions to the permanent endowment and equipment of these institutions was for the same year estimated at $6,055,146·80. I regret that the time has been too short to permit of collecting statistics from other countries as to what sums are annually expended by them on agricultural educational institutions. Such information would be valuable, and would show us to what extent it has been regarded as wise and profitable to maintain such institutions. We know however that many countries with no greater population than the West Indies and with far smaller agricultural resources than we have do support agricultural colleges and schools of the highest standing. An awakening to the importance of agricultural education to the British Empire has taken place of late years, and an excellent review of what has been accomplished up to ten years ago has been given by R. Hedger Wallace in his paper Agricultural Education in Great Britain, read before the foreign and colonial section of the Society of Arts, February 1900. Since that time advances have been made in the Australian Colonies, in South Africa, in India and in Canada, but in the West Indies I fear that we have 'marked time'. That the West Indies are split up in several small colonies may make concerted action somewhat difficult, yet it should not be permitted to hamper national or imperial progress. The people of the West Indies are not slow to grasp whatever is to their advantage, and will not hesitate to avail themselves of opportunities offered, no matter whence they come. Education is highly prized and earnestly striven for, as is evidenced by the great number of our young men who

yearly go abroad to study professions. There is no reason to believe that the opportunity given to acquire in their own lands a profession as honourable and remunerative as any, would not be embraced.

Is agriculture as remunerative in the West Indies as are other professions or vocations?

An endeavour has been made to collect reliable data bearing on this question. A number of physicians, barristers, solicitors, civil service men, merchants and planters have been consulted, and on the information kindly given by them the following statements are based.

Physicians: To qualify in minimum time, living expenses included, £1,000. Average earning capacity £500 per annum. Average length of period of earning 30 years.

Barristers: To qualify in minimum time, living expenses included, £800. Average earning capacity £500 per year. Average period of earning 35 years.

Solicitors: To qualify in minimum time, living expenses included, £500. Average earning capacity £350 per year. Average length of period of earning 35 years.

Civil Service: Average age and salary when entering service, 19 years and £50 per annum. Length of service before receiving a yearly salary of £200, ten years. Fifty-five per cent. of civil servants attain to offices from £150 to £250, 25 per cent. from £300 to £350, 12 per cent. from £350 to £450, and 4½ per cent. from £500 upwards per year.

Merchants: Information has been obtained from wholesale and large retail firms by means of a letter in the form of a circular containing questions. These questions with replies, given in figures of averages, are as follows:—

(1) What is the average age at which young men enter your employ?

Answer. 15 to 18 years.

(2) At what salary do they begin?

Answer. £30 per annum?

(3) How long before they earn £100 per annum?

Answer. 4 years.

(4) How long before they earn £200 per annum?

Answer. 7 years.

(5) How long before they earn £300 per annum?

Answer. 15 years.

(6) What percentage of employees reach a salary of £300 per annum?

Answer. 8 per cent.

(7) What percentage of employees reach a salary of £400 to £600 per annum?

Answer. 3 per cent.

(8) What percentage of employees reach a greater salary than £600 per annum?

Answer. $\frac{1}{2}$ per cent.

(9) What percentage of employees embark in business on their own account?

Answer. $\frac{1}{5}$ of 1 per cent.

Inquiries among small retailers (shopkeepers, etc.) resulted in a wage scale of £15 to £100 per year. About 40 per cent. of employees reach the highest salary. About 30 per cent. go into business on their own account and reach an average earning capacity of from £150 to £300 per annum.

Artisans. Average age at which trades are taken up, 17 years. Average earning capacity for the first three years, £30 per annum. Maximum average earning capacity £100 to £150 per annum.

Agriculture. A letter similar to that addressed to merchants was sent to planters with the following result :—

(1) What is the average age at which young men enter your employ?

Answer. 18 to 22 years.

(2) At what salary do they begin?

Answer. £60 per annum.

(3) How long before they earn £100 per annum?

Answer. 2 years.

(4) How long before they earn £200 per annum?

Answer. 5 years.

(5) How long before they earn £300 per annum?

Answer. 10 years.

(6) What percentage of employees reach a salary of £300 per annum?

Answer. 17 per cent.

(7) What percentage of employees reach a salary of £400 to £600 per annum?

Answer. 8 per cent.

(8) What percentage of employees reach a greater salary than £600 per annum?

Answer. 2 per cent.

(9) What percentage of employees embark in agriculture on their own account?

Answer. 11 per cent.

It will be seen, that advance is far more rapid in the agricultural line than it is in the mercantile line or among artisans, that a larger percentage of employees reach higher salaries and that a far greater number of employees of the agricultural class become proprietors than of the mercantile class, excepting small retailers.

A comparison of the earning capacities of agricultural employees and civil servants results in a decided advantage to the former from a financial standpoint. The most attractive feature connected with the civil service is that of pension on retirement. Except when the higher posts have been reached this pension is not great, and it is doubtful if its monetary value is as large as that of the perquisites generally enjoyed by employees in the agricultural line.

It seems that the average earnings of the medical and legal professions are somewhat in excess of the earnings of agricultural employees, but so are the expenses incidental to these callings. In this connexion it is well to remember that the demand for medical and legal practitioners is much more restricted than the demand for agriculturists. The former vocations will soon become overcrowded, while for the latter there is a well-nigh unbounded scope in the West Indies and the adjacent countries of Central and South America.

The financial prospects of only one class of agriculturist have been considered so far—the salaried men. The proprietors form another large group. To compare the earning capacities of capitals invested in agricultural and in mercantile undertakings is very difficult. In both cases much depends on the individual capabilities of the investor. Some of the greatest and strongest firms have started with the scantest of capitals, and so have some of our largest estate owners. In both cases success has been due to intelligent management and close attention to the work in hand. It has been estimated that capital invested in agriculture in the West Indies returns an interest of about 20 per cent. If, on the average, mercantile investments exceed this percentage cannot be stated here, but that the agriculturist runs far less risk of losing his capital than does the commercial man is easily ascertained, by comparing the numbers of failures in the two classes recorded in our courts. It will be understood that the bulk of these statistics have been secured in Trinidad, only limited information being received from the other colonies. Yet conditions in the aggregate in the West Indies are so similar that statements valid for one colony are approximately so for all.

After this review of the financial aspects of the various callings, it would seem that the answer to the question: 'Is agriculture as remunerative in the West Indies as are other professions or vocations?' must be affirmative. Apart from monetary considerations will come the laudable aspiration of young men to a social recognition incidental to the status of a professional man. No harm can come from the gratification of worthy ambition. In this connexion may be considered the complaint which has come from India, that young men will attend institutions primarily intended for the training of agriculturists and afterwards never follow that profession. It reads: 'These institutions have not, on the whole, attained their object. They have been for the most part frequented by students who regard the course as an avenue to employment in the Land Revenue and Agricultural Department, Court of Wards, or in other similar Departments of the Government, and the number of students who have sought the schools with a view of

improving the methods used on their own property, or in the expectation of finding employment among native land holders has been very small.' It is pleasing to note that such a state of affairs did not deter the Government of India from continuing its efforts on behalf of higher agricultural education. It had the opposite effect, and the state and efficiency of agricultural colleges were raised and due regard given to strengthen the social position of their graduates by the Resolution of 1897: 'That agricultural degrees, diplomas and certificates should be placed on the same footing as corresponding literary and science degrees.' When a majority of the qualified men desert a profession to train for which they have devoted years, it is safe to say that the training has been faulty—it has not infused the students with enthusiasm and love for the work, it has failed to imbue them with the dignity of a profession which makes them producers of wealth in place of more distributors of a wealth created by others.

We have seen that the cost of medical or legal training ranges from £500 to £1,000. At what cost can training for the agricultural profession be secured? In Hart's paper, previously quoted, is pointed out the necessity for two grades of higher agricultural education. This is the plan generally adopted. The lower grade is known as the agricultural school at which future sub-managers and overseers are trained. In the schools the instraction is free, the students giving their labour in return. The course is generally two years. The highest grade of agricultural education is imparted in the agricultural colleges, the course being from three to five years. The fees vary much in different countries. They are lowest in Continental Europe, highest in the United States and England; £200 for tuition is the average. To this will be added the living expenses which as a rule are not high, owing to the fact that agricultural colleges must necessarily be located in rural districts. The cost of training for the agricultural profession is therefore not greater than for the medical or legal profession, but frequently lower. Many agricultural colleges enjoy rich endowments provided by public-spirited and generous citizens, which enable them to reduce the expenses of their tuition so low that they may be regarded as almost nominal. In the United States, revenues derived from land grants are frequently sources of considerable income to schools and colleges teaching agricultural science.

Although it does not come within the scope of this paper to discuss the organization and lines of work of agricultural schools and colleges, yet a cursory glance at the functions of such institutions and their relative positions among establishments and organizations for the furtherance of agriculture would assist us in arriving at a true recognition of their importance and may also provide us with a plan on which to base a project for higher agricultural education in our part of the world. As to the manner in which these institutions are supported, very slight differences will be found. They are located on estates or farms owned by the Government. Buildings and equipments are derived either from general revenue, special taxation or the income from land grants. Maintenance

is provided from general revenue or from a tax specially levied for the purpose. In the scope of their work their institutions vary very considerably in different countries. A careful scrutiny leads to the conclusion that the best pattern for the West Indies is furnished by the United States. There are several reasons for this. The subject of agricultural education has received more attention there than in any other country, with the result that a great amount of good work has been done in this direction. This does not mean that the other agricultural schools and colleges of other nations are not of as high standing, as well equipped and as efficient in their training, as are those of the United States, but that the United States derive a greater benefit from their establishments. Another reason will be found in the analogy between the Colonies forming the British West Indies and the States combined in the Union—they are both parts of a whole with local governments, colonial or state, under one central government, imperial or federal. In reply to a request for information concerning agricultural education in general in the United States and the relative functions of the United States Department of Agriculture, the State Departments of Agriculture, the Agricultural Colleges and Schools and the Agricultural Experiment Stations, the following letter was received from the United States Department of Agriculture, Office of Experiment Stations, under date of November 30, 1910 :—

'Dear Sir,

'Your letter of November 1 to the Hononrable Secretary of Agriculture has been referred to me. I am sending you publications which cover most of the points of your enquiry concerning agricultural education and research in the United States. From these you will see that each State maintains an agricultural college, one or more agricultural experiment stations and has some sort of organisation corresponding to a Department of Agriculture. In about half of these States these organisations are called Departments of Agriculture, and in others they are called State Boards of Agriculture. The functions of these departments vary considerably in detail but in general they are executive Departments and Boards maintained for the purpose of collecting and publishing agricultural statistics and executing state laws with reference to fertilizer, food, and feed control, crop pest regulations, etc. In some instances research work is done in the laboratories of the State Department of Agriculture, and a few of these state departments, as in North Carolina, conduct regular experiment stations. Some of the agricultural experiment stations connected with the colleges of agriculture are charged with carrying out the state regulations with reference to fertilizer and fruit control, crop pests, etc. The statistical publications sent you will show the amount received by each institution from the federal government and also from the state or local government.

'The United States Department of Agriculture co-operates with these various state agencies in control regulations as far as these are inter-state in character, and also co-operates with

them in certain investigations of wide general importance. In addition to these co-operative enterprises, this Department also carries on some independent investigations.

'Education is primarily a function of state institution and the federal government does not exercise control of any sort over these state institutions except as to the expenditure of federal grants according to definite regulations prescribed in the laws granting these funds. However, there is a Federal Bureau of Education connected with the United States Department of the Interior which is charged with the collection of statistics concerning education in general and jointly with the Office of Experiment Stations of this Department collects and publishes statistics concerning agricultural education. It also acts in an advisory capacity with relation to all educational institutions throughout the United States.

'In a somewhat similar way the Office of Experiment Stations of this Department maintains advisory relations with institutions giving instruction in agriculture. It collects and publishes statistics as noted above, prepares suggestive courses of study for school and different grades for colleges, consults with school authorities, and in general performs clearing-house functions for the agricultural institutions of the country.

'If I can be of any further service to you kindly let me hear from you.

'Yours very truly,

'D. J. Crosby,
'Specialist in Agricultural Education.

'To Dr. A. Fredholm,
'Agricultural Society of Trinidad,
'Trinidad, B.W.I.'

Here the division of labour between the various institutions is given. There is a federal Department of Agriculture which co-operates with all state institutions in an advisory capacity but exercises no control over them except as to the expenditure of revenues derived from federal grants. This Department also gathers and publishes statistics, and conducts experimental and research work at its experiment stations.

The State Departments or State Boards of Agriculture enforce the laws referring to agricultural affairs, and publish statistics. Their duties are mainly executive in character and only in a few instances do they control institutions connected with researches and experiments.

The Agricultural Colleges have charge of agricultural education of the highest grade, and with them are generally united Experiment Stations. Such unions have been found advantageous for both scholastic and economic reasons. It should however be noted that in these cases the agricultural colleges are regarded as the ranking institutions—the experiment stations as adjuncts. The agricultural colleges are sometimes also delegated with the executive duties which generally devolve on the State Departments of Agriculture—another evidence of the paramount importance of the colleges among the other agricultural institutions.

The State Agricultural Experiment Stations engage in research and experiment work, but do not enter on educational labours.

This division of duties has been found conducive to most satisfactory results. Independence of action, yet co-operation to an extent which prevents overlapping, is arrived at.

It would appear that a similar scheme could easily be followed in the West Indies—in fact we are not far from it now—only some additions to, and minor alterations and re-adjustments of, our present agricultural institutions are required. We have the Imperial Department of Agriculture, well equipped and with an efficient staff, already doing in the main the work of the United States Department of Agriculture. In the smaller islands this Department partly maintains, and to a certain extent controls, stations, mostly engaged in experimental work. In some colonies, Departments or Boards of Agriculture exist, which employ a corps of officers also conducting investigations—nowhere are agricultural schools or colleges to be found.

For each colony to maintain an agricultural college would probably be a waste of money, but one or two of the larger colonies could well afford to establish such institutions, devoting part of the revenues now enjoyed by the Departments and Boards of Agriculture for research and experimental work to educational purposes. To continue investigations in matters pertaining to agriculture is absolutely necessary and experiment stations must be maintained for the conduct of this line of work. In order to secure co-operation in research and experimental work and avoid overlapping it would seem desirable that all stations should be under one control. To exercise such supervision the Imperial Department would be eminently fitted and it might be possible that in such a case the Imperial Government if approached, could see its way to grant a subsidy sufficient for an experiment station in colonies devoting their revenues to agricultural education of collegiate grade.

The botanic and other stations now established in the smaller islands could be converted into agricultural schools. The maintenance of such institutions, when run on proper lines, is not great, as they are to a considerable extent self-sustaining—in some cases entirely so. The schools could be supported from the revenues of the island in which they were located, and the funds now contributed by the Imperial Government would continue to support the experiment stations.

As before stated, the presentation of a scheme for higher agricultural education suited to the needs of the West Indies is beyond the scope of this paper. The aim of the foregoing paragraphs has only been to indicate, without entering into details, how far the existing agricultural institutions and organizations of these colonies can be utilized for educational purposes, and agricultural schools and colleges be established to supplement the good work now being done by these institutions and organizations.

At the meeting of this Conference in 1908, the question of agricultural education was brought up for discussion by Dr. Watts. He brought forward a suggestion for the instruction of overseers by means of home reading courses and examinations; certificates were to be awarded to the successful students. A comprehensive syllabus was arranged. The Imperial Department of Agriculture inaugurated the scheme and has been energetically forwarding it ever since. Its publications – the *West Indian Bulletin* and the *Agricultural News*—have devoted many pages to its furtherance. In the latter a page—the Students' Corner – is especially set aside for the purpose. There is no doubt that some measure of good has resulted, but has it been sufficient to influence in any way the agricultural practices in the West Indies? Here and there young men may be found who have attained some useful knowledge, but the opportunities afforded them to put their theoretical acquirements to practical uses must be limited. The course is intended for overseers and sub-managers. These men hold subordinate positions : they are employed to carry out orders received ' and it is somewhat dubious if their suggestions or criticisms of present methods would be kindly regarded by proprietors and managers. They have graduated from the hard school of practical experience, and would naturally be somewhat diffident in entering upon unknown paths. They would be somewhat wary in accepting suggestions arising from purely theoretical knowledge. They know that their employee is earnest and ambitious, but also that he can have no knowledge of new methods apart from that acquired through reading : he has never practised them himself, nor seen them applied by others. Professor Carmody drew attention to the fact that local certificates carried no weight with the employer of men. May the reason for this not be sought in the realization of the fact that the essential of all technical training—experience in its application—is lacking in the holder of the certificate? A few rebuffs, a few unsurmountable obstacles placed in the way of a young man, may quench his enthusiasm and lead him to follow the line of least resistance, drifting in the old way. In later years he may become a proprietor or manager and then proceed to apply the knowledge acquired, only to find that it has not been far-reaching enough. It would have been useful to him as an overseer, when it could not be applied, but it does not materially assist in the solution of the greater problems confronting the man in a more responsible position. Home reading courses may be useful modes of acquiring knowledge on certain subjects purely deductive in character, but their value in studies requiring facilities for observation, demonstration and experiments is doubtful. It would be difficult for anyone who has never entered a biological or a chemical laboratory to grasp the work done in such places, to picture before his mind a microscopic slide when he has never seen a microscope, or to follow the processes of assimilation, transpiration and respiration without having had access to chemical and physical appliances. The question may well be asked : Would not the young men derive more benefit by devoting a couple of years of their time and of their labour to a course

provided in agricultural schools where they could acquire a fundamental knowledge of the sciences underlying agriculture and see and take part in the practical application of them?

These courses are not intended for managers or proprietors; for them nothing is provided, and they are worse off for educational facilities than are the overseers. Education is necessary to all classes of men and useful under all conditions. It exerts a levelling influence, but its mode of dissemination does not appear to present any analogy to the physical activity known as capillarity, but rather to that of percolation—it does not rise upwards from lower strata but slowly permeates by sinking down from above.

Higher agricultural education could not fail to exert far-reaching effects in the West Indies. It would be of great economic consequence, because it would provide a trained body of men to conduct the main industry of the colonies; our youths would have opened to them a new field in which their energy and ambition could be most usefully employed both for the good of their own future and for the good of the British Empire. Mr. Roosevelt once said: 'The farmer stands for what is fundamentally best and most needed in national life.' All classes of agriculturists would benefit—trained proprietors, managers and overseers would tend to increase the skill of the labourers: in the agricultural schools the opportunity would be given our peasantry to acquire an education suited to their demands and at a cost within their means.

The need in the West Indies for agricultural education of a higher grade has often been admitted and the subject so frequently discussed that it would seem that little now remains to be done except to take definite action on the many suggestions which have been made from time to time. 'The consideration of means for advancing the material prosperity of these Colonies, is the object of these Conferences. May not this, the eighth West Indian Agricultural Conference, devote some of its energy to procuring for these agricultural colonies higher agricultural education?

A LECTURESHIP IN TROPICAL AGRICULTURE.

BY SAMUEL SIMPSON, B.Sc., M.R.A.S.E., N.D.A.

The Departmental Committee appointed in 1908 by the Board of Agriculture and Fisheries to enquire into, and report upon, the subject of Agricultural Education in England and Wales, produced a substantial volume of much evidence and made many strong recommendations.

The whole field of education bearing upon agriculture and closely allied subjects was minutely surveyed and critically examined, and already organized work on the basis advocated by this committee is being carried out. Thus at last a complete system of agricultural education is being evolved out of the chaos which previously existed. Far-reaching results are certain to follow, and these will cause a big uplift in the practice and science of British agriculture in the near future.

Although quite outside the scope of the enquiry, two or three witnesses touched upon the subject of Colonial and Tropical Agriculture. It was stated by one of them that, but for the existence of agricultural departments at the Universities of Cambridge and Edinburgh, an Indian Department of Agriculture as now constituted, would have been impossible.

Obviously impressed with the possibilities and potentialities of this branch of work, the committee put on record the opinion that universities, in making provision for the training of agricultural experts, are doing not only a national but an Imperial work, and one of their principal conclusions and recommendations was to the effect that it would greatly assist in the provision of suitable agricultural experts for the development of British tropical and sub-tropical Colonies, if a Readership or Lectureship on Tropical Agriculture were established at one or more British Universities.

Nothing has yet been done to carry out this proposal, which is a pressing necessity. Important as is the subject of home agriculture, the agriculture of our tropical, sub-tropical and colonial possessions means their very existence. Everything depends upon the successful carrying out of agricultural operations, and the cultivation of the various crops suited to the local conditions of soil and climate.

The diverse crops cultivated, and the extraordinary amount of the world's commerce dependent upon them, cover such wide fields and vast interests, that it is passing strange that Great Britain has failed to make a systematic attempt to train those who are destined to carry on and direct agricultural operations under tropical and sub-tropical conditions.

Perhaps a better idea of the interests involved can be obtained by just mentioning a few of the staple products. These are tea, coffee, cacao, sugar, foodstuffs such as rice and maize, tobacco, rubber, cotton and other fibres, oils and oil-seeds as well as many others of great importance.

The Imperial College of Science, South Kensington, should by all means be the first place at which such an urgently

needed lectureship is instituted. Already it has appointed a Professor of Plant Pathology, and gives lectures and practical training in economic entomology, both subjects being treated more particularly with the view to training scientists for work in connexion with tropical and sub-tropical regions. But this is only a beginning, and something more comprehensive must be attempted. Annually, scores of men leave Great Britain, to take up agricultural work, ill-equipped for their duties, and possessing practically no knowledge of the conditions and crops which are to be their special care in the future. This is a national disgrace which could to some extent be remedied by providing opportunities for a short training at some centre. The advantage of the Imperial College of Science is that it is convenient for studying the resources of Kew and the valuable collections of products exhibited at the Imperial Institute; whilst the courses given at the College provide a scientific basis for workers intended for tropical and colonial development.

Great Britain has willingly sent millions of money to develop estates in her own colonies and dependencies. She has also taken a foremost part in providing money and men in the territories of other powers, but up to the present time little has been done to provide facilities for training the men who are to conduct those overseas operations. In the past this has meant great wastage and much unnecessary loss. Absolute failure has been the result in many cases, due entirely to lack of knowledge; whilst in others, partial success only has been attained owing to the cropping and treatment being unsuited to the prevailing conditions.

The world's demands are rapidly increasing, for every kind of produce, and with this increasing demand there is a strong tendency for prices to rise permanently to a higher level.

With our tremendous interests involved, every effort should be made to spread knowledge concerning the cultivation of these various crops which mean so much for mankind in general, and to Great Britain with its ever expanding commerce, in particular.

It will be a small step forward when something is done to provide for the training of men who are entering the ranks of those practically engaged in the cultivation of the various crops of the world.

PEASANT AGRICULTURE IN GRENADA: SUGGESTIONS FOR ITS CONTROL AND IMPROVEMENT.

BY GILBERT AUCHINLECK, B.Sc., F.C.S.,
Superintendent of Agriculture, Grenada.

The conditions in Grenada, and its dependency Carriacou, in regard to peasant ownership of land differ somewhat from those which exist in some of the other, smaller West Indian Islands. When we consider the great value of Grenada's chief export, cacao, and the fertility of the lands in Carriacou, we are struck by the extent to which peasant ownership continues to exist in the Colony. The following summary issued by the Treasury Department shows the number of small holdings on which land tax was levied during the year 1911, and also the approximate areas of various classes of Holdings.

SUMMARY OF OWNERS OF SMALL HOLDINGS FOR THE YEAR 1911.

District.	Number of owners of Small Holdings.				
	2½ acres and under.	Over 2½ to 5 acres.	Over 5 to 7 acres.	Over 7 to 10 acres.	Totals.
St. George's	1,000	250	67	38	1,355
St. David's	1,005	253	68	51	1,377
St. Andrew's	1,676	367	87	52	2,182
St. Patrick's	834	161	46	31	1,072
St. Mark's	209	61	14	19	303
St. John's	661	100	31	15	807
Carriacou	947	262	31	13	1,253
Total	6,332	1,454	344	219	8,349

These figures are instructive. If we adopt certain average acreages for the classes of holdings enumerated in the table we get a fairly accurate idea of the total acreages owned by peasants :—

Column I	6,332 at ¾-acre average	=	4,000 acres.
„ II	1,454 „ 3 acres „	=	4,300 „
„ III	344 „ 6 „ „	=	2,000 „
„ IV	219 „ 8 „ „	=	1,700 „
	Total		12,000 acres.

These figures refer to land actually owned by peasants, and do not include such areas as are in the hands of tenants on larger estates. No returns are available as to the proportion of these lands which is under cultivation, but as most of the areas of the higher ridges are owned by the Government, or retained in forest by special arrangements with private owners, we may assume that most of the 12,000 acres, if not cultivated, is at any rate cultivable.

The total area of Grenada and Carriacou is estimated at 85,000 acres, of which 2,800 acres is comprised in the Government Forest Reserves. The area in Carriacou which, according to the table above, is owned by peasants, is 1,700 acres, and the total area of the island 8,000 acres. We thus get the following figures :—

Class of Holdings.	Carriacou, acres.	Grenada, acres.
10 acres and under	1,700	10,300
Over 10 acres	6,000	64,200
Forest	300	2,500
	8,000	77,000

By calculating the proportion existing between the total area of small holdings owned by peasants and the total area of those over 10 acres, we obtain a figure which may suitably be called the *ratio of peasant ownership*, a figure which concisely expresses the state of affairs in each island of the Colony.

$$\text{Carriacou} \quad \frac{1{,}700}{6{,}000} = 1 : 3{\cdot}5$$

$$\text{Grenada} \quad \frac{10{,}300}{64{,}200} = 1 : 6{\cdot}2$$

That is, for every acre owned by peasants there are in Carriacou 3·5 acres and in Grenada 6·2 acres owned by larger proprietors, or, to put it in another way, slightly less than one-quarter of private-owned lands in Carriacou and slightly less than one-seventh of those in Grenada are in the hands of peasants.

Comparative Efficiency of Small Holdings.

When we attempt to estimate the production of marketable crops on peasant holdings in order to compare their efficiency with that of larger estates we are met by great difficulties. The foodstuffs which are produced locally are consumed locally, and as there are no available records of the relative areas cultivated in the various crops only mere guesses as to their production are possible. Similarly in the case of exported

products such as cacao and cotton, it is impossible to separate peasant-produced stuff from that of larger estates. By careful consideration of certain facts we may deduce approximate figures which should be of some value to us as indications of the probable state of affairs.

In 1910 there were ninety-six licensed cacao dealers in Grenada, and the number has probably increased in 1911. If we assume that all the cacao handled by dealers was produced by small owners—and this assumption is reasonable since all the larger owners ship independently through their agents, and if we estimate the annual average trade per dealer as 50 bags, we arrive at the conclusion that about 5,000 bags of cacao from small holdings is annually produced and marketed. The value of this would be about £20,000.

An analysis of the Cacao Prize-holdings entrance returns for 1910 affords some useful indications.

No. of holdings.	Size of holdings.	Probable average area.	Total acreage.
135	under 2 acres	½-acre	70
36	2 ac. to 5 ac.	2 acres	80
33	3 ac. to 5 ac.	3 „	100
			250

Allowing for an average yield of 1½ bags per acre of cured cacao from this area, the returns of the Cacao Prize-holdings Scheme, which includes only a limited proportion of peasant cacao producers, indicate an annual crop of 375 bags, worth £1,500.

Probably an estimate of £10,000 per annum as the value of cacao produced by peasants would be below the mark.

The exports of cotton and cotton seed from Carriacou is given in 1909 as amounting in value to £9,000. As about one-fourth of the land is owned by peasants, we may safely place a value of £2,000 on peasant-produced cotton.

In 1910 there were in operation in Grenada about sixty small sugar mills, most of them operated by horse-power; these would probably need 200 acres for their support, and the total output would be about 300 tons of 'wet' sugar, worth approximately £2,400.

Such crops as maize, bananas and vegetables are produced on a fair scale, but there is no way in which their annual value can be determined. If we assume that each peasant owner produces every year these crops to a value of 10*s*., the total value would be £4,000.

Keeping in mind that all the items are mere approximations, we may compile provisionally the following table of annual values for peasant products:—

Cacao exported	£10,000
Cotton and cotton seed	2,000
Sugar	2,400
Foodstuffs	4,000
	£18,400

The value of the foodstuffs and marketable agricultural products exported from Grenada and Carriacou in 1909 was £260,000, of which we have calculated £18,400 to have been produced on peasant-owned lands. The ratio of peasant products to those of large estates then will be :—

$$\frac{£18,400}{£243,000} \quad \text{or} \quad 1 : 13{\cdot}2$$

This ratio may conveniently be called the *monetary ratio of peasant production*, or more shortly the ratio of peasant production, and in this case it shows that for every £1 produced by peasants there are £13·2 produced on larger estates. It is obvious that the monetary production per acre of peasant-holdings can never equal that per acre on large estates, since the crops produced as a rule on the former, however efficiently they may be handled, are actually of a lower market value, being different in kind.

The ratio 1 : 13·2 is based on mere approximation, but even allowing that it should be raised as high as 1 : 10, it still is by no means commensurate with the ratio of peasant ownership, and there obviously exists a fair field for measures of improvement. These two ratios are of decided interest when regarded as attempts to place on a definite statistical basis the main facts of ownership and production in the Colony.

Defects in Agricultural Methods of Peasants.

The defects of peasant agriculture in Grenada and Carriacou are measured in the aggregate by the small yield obtained per acre in the various crops—an effect which may be directly attributed to inefficiency in cultural methods and impoverishment of the soil. The history, given by a peasant owner to the Agricultural and Commercial Society of his holding, affords food for thought: in the first year of his entrance for the Prize-holdings Competition his land yielded him 13 bags of cured cacao (2,340 lb): two years later, as a result of manuring and tillage, the yield rose to 30 bags (5,400 lb.), representing an increase of £60 to £70.

Cacao cultivation in the hands of peasants has so often been ably criticized by members of the Agricultural and Commercial Society that it is comparatively easy to point out the chief defects. The annual pruning so necessary to orchard cultivation is either neglected or carelessly carried out; young basal shoots are not removed; forking is neglected, and draining ineffectually performed; house refuse suitable as

manure is wasted. Generally, we may sum up by saying that the attention to detail and the keen desire for improvement which go so far towards replacing actual money capital are too often absent.

The Carriacou peasant is usually regarded as more thrifty, and he possesses some capital, but a visit to his holding will usually disclose some defects which need remedying. His cotton is ratooned (or cut back) year after year without replanting—a practice which must result in decreased returns. Five to ten distinct types, all jumbled under the general name 'Marie Galante', and some of which are commercially undesirable, are found intermixed without attempt at selection. The attacks of the cotton caterpillar are in some cases deliberately fostered, since the defoliation of the plants retards the fruiting period until a reaping season more convenient to the owners.

The sugar-cane cultivation owned by peasants in the south of Grenada suffers from the same bad management. Stools or clumps are never replanted, and manuring is deficient.

Maize is handled badly. The land is invariably burned before planting and manuring is never practised; no systematic selection of seed is carried on. As a result, when by manuring and effective tillage a minimum yield of 50 bushels might be obtained, a yield of 10 bushels is regarded as a fair return.

The Causes of Inefficiency.

The factors lying at the base of the inefficiency of small holdings in the West Indies, and in the Tropics generally, are too well known to warrant any lengthy description. They may be stated to be (a) lack of capital, (b) lack of education, (c) lack of manual training, (d) absence of any climatical necessity for hard work. These various factors are so closely connected with one another that in far the greater number of cases we find it impossible to deal with them separately. The question as to the effect of an influx of a large amount of capital made readily available on business lines has been already answered by the enormous prevalence of hopeless mortgages on small holdings, and the natural conclusion that readily available capital, without scrupulous application of it to the land and intensive methods of cultivation, ends only in embarrassment is almost unavoidable. It is a moot point whether capital without education or education without capital be the more ruinous.

One point which stands out clearly throughout these investigations is that, in dealing with small holdings in the West Indies, some strong organization, external to the peasant community, is necessary if increased efficiency is desired, and that this organization must take into consideration all the factors enumerated above if any degree of success is to be hoped for Naturally, the Government suggests itself as the most suitable organization, controlling as it does a certain amount of common capital and having at its disposal an adequate staff.

Ethics and Economics of Peasant Control.

Arrangements for the effective control of small holdings may all be reduced to one of three following classificatory heads:—

A. Commercial reasons: the actual increase of wealth to the Colony.

B. Natural and legitimate attempts to improve conditions of life in the Colony, and to increase efficiency of labour.

C. Measures to protect efficiently handled cultivations from diseases neglected by small owners,

and these three heads constitute an analysis of what is usually vaguely described as progress. The commercial question is designedly placed first, as being the one on which the means of progress depends and in many cases affording the inducement for efforts at progress.

When we take into consideration the facts that an area of 12,000 acres exists in the Colony, the greater part of which is capable of improvement, and that large sums are annually sent from the islands to purchase stuffs which might readily be produced locally, we realize that aid and advisory control by some stable centralizing body is a definite necessity. An increase of 5s. per acre in the value of products from peasant lands would give £3,000 per annum extra wealth to the Colony.

Some idea of the opportunities which exist for the development of new industries or the increase in efficiency of existing methods may be gleaned from the following returns of imports into the Colony for 1910. Only those crops and industries which may be regarded as pertaining to peasants are dealt with:—

Item.	Value.
Goats, cattle, mules, sheep, swine, poultry ...	£960
Maize	418
Cornmeal (maize)	697
Stock feed	2,370
Fresh fruit*	80
Potatoes (English)	396
,, (sweet)	160
Yams	159
Rice	6,188
	£11,428

The much debated point of the advisability of advocating attention to crops of low market value when an extremely profitable crop such as cacao would actually draw large sums of money into the island may be an important one, but to one who knows the Colony there can be little doubt that

*N.B. Nine years ago Grenada *exported* £800 worth of fresh fruit.

sufficient land unsuitable for cacao exists to afford scope for reducing the above sum of imports without lessening the output of the more valuable products. The real question of importance is not the relative value of cacao and food-crops, but the tendency towards neglect of lands unsuitable for cacao but suitable for other crops which has followed on the undue emphasizing of the value of cacao.

In cases where neglect of holdings tends to possibility of monetary losses to the adjoining proprietors, such as we find to be the case with attacks of plant diseases or the spread of parasitic growths, a Government will usually not hesitate to step in with suitable legislation. These are cases where the community suffers from the carelessness of individuals, and good instances may be found in the legislation against the dodder (Cuscuta) on limes and cacao, legislation against bud rot of coco-nuts and 'noxious weeds' Ordinances. The first and third of these enactments now (January 1912) exist in Grenada.

When we turn to consider the question of increasing the efficiency of the agricultural work of peasant owners we find the case much altered. Neglect which does not actually endanger the monetary profits of one's neighbour's holdings is not a suitable subject for legislation, and it is interesting to note the many devices which have been adopted to replace compulsory labour. We may briefly classify these devices under the following heads:—

A. Measures of inducement,
B. Measures of capitalization,
C. Measures of instruction.

The necessity for the first of these measures, 'inducement', is the point which differentiates tropical peasant agriculture from that of temperate climates.

These measures have by no means been neglected in Grenada and Carriacou, and since this paper may properly be regarded as an investigation into the adequacy of existing methods, it will be of interest to describe briefly the aims and scope of a few of the most important ones. Under the first heading we may class the Cacao Prize-holdings Competition in Grenada, the Carriacou Prize-holdings Competition, prizes for vegetables and fruits in the market, and agricultural shows; the second includes the Land Settlement Scheme in Carriacou, the Land Settlement Scheme in Grenada, and the erection by Government of a sugar mill in Grenada and a cotton-ginning factory in Grenada and Carriacou; the third includes the foundation of an Agricultural Instructorship, and the organization of peasant meetings.

EXISTING MEASURES OF INDUCEMENT.

PRIZE-HOLDINGS COMPETITIONS. Two of these are at present in operation, one in Grenada and the other in Carriacou.

The Grenada scheme originated in 1906, when Mr. R. D. Anstead, B.A., then Agricultural Superintendent, laid plans before the Agricultural and Commercial Society which were subsequently adopted and put on trial in one parish of the

island. It has grown considerably and now includes all parishes of the island: the entries for the last three years give some idea of the scope and extent of the scheme:—

1909	219	entries
1910	205	„
1911	135	„

Holdings are divided into three classes. those under 2 acres, 2 to 4 acres, and from 4 to 5 acres, and valuable money prizes are awarded in each class. The prizes are as follows:—

Class I (4 to 5 acres)	1st	£3 10	in each parish
	2nd	£2 10	„
	3rd	£2 0	„
Class II (under 4 to 5 acres)	1st	£3 0	„
	2nd	£2 10	„
	3rd	£2 0	„
Class III (under 2 acres)	1st	£3 0	„
	2nd	£2 0	„
	3rd	£1 10	„

The scheme is controlled by the Agricultural and Commercial Society, which appoints judges, distributes prizes and generally makes necessary changes and modifications. The Government finances the scheme to the extent of £165 per annum, and the Agricultural Department is required to give necessary instruction to entrants.

This scheme is most valuable to Grenada, having the advantages of efficiency which follow upon confinement to one crop, cacao holdings alone being eligible. If this scheme were supplemented by a competition for crops other than cacao, most valuable results should be obtained.

The Carriacou Prize-holdings Scheme is a new venture initiated in 1910, and not yet thoroughly organized. Maize, cotton and vegetables are the crops eligible for competition. Efficiently handled, this scheme should extend considerably, with most beneficial effects.

PRIZES FOR VEGETABLES IN THE MARKET. This scheme was put into operation in 1910 in Grenada by the Agricultural and Commercial Society, being devised to encourage increased production of vegetables and fruit. The Government voted a sum of $60 (£12 10*s.*) to be dispensed in prizes. Prizes vary from 1*s.* to 2*s.* 6*d.*, and surprise visits are paid in each alternate month by judges appointed by the Society. As a supplement to some more extensive scheme of control of vegetable-growing this scheme might be of great value, but at present it leaves the way open to fraudulent exhibitors.

MEASURES OF CAPITALIZATION.

LAND SETTLEMENTS. There are two schemes of land settlement now existing in the Colony. In 1900 the Government was empowered to value and purchase lands in Carriacou, employing surplus funds of the island for the purpose, and to survey the area into lots suitable for peasants. A total of about 1,200 acres has been acquired, and the returns to date (December 1911) are as follows:—

Total cost price.	Acreage.	Govt. forest, pastures and water reserves.	Received for sale of lands.
£ 6,250	1,300	300 acres.	£ 6,450

The Grenada Land Settlement Scheme was initiated in 1910 by the voting of £5,000 from the surplus funds. So far two estates totalling 450 acres have been acquired, and the figures following show the position of affairs:—

Total acreage.	Cost.	Acreage sold.	Reserves.	Acreage unsold.
450	£1,762	150	100 acres	200 acres

In both schemes the terms of payment are businesslike but liberal. An allottee may pay 25 per cent. of purchase money, and enter into possession; for the next three years he pays 5 per cent. interest on the outstanding balance, and then for nine years he pays the balance in nine instalments. As an alternative he may pay one-twelfth of the cost annually for twelve years, plus interest on outstanding balances. No allottee is allowed to alienate his holding, in whole or part, for the term of twelve years.

The benefits of these schemes can hardly be exaggerated: acquirement of land, freedom from exorbitant usury, co-operative enterprises, centralization of products, provision of roads and of a pure water-supply, and facility in approaching the Government are all placed within reach of the peasant: while labour will be in the end rendered more stable and efficient.

MISCELLANEOUS. A small cotton-ginning factory has been erected in Carriacou for the benefit of peasants, followed in 1911 by one in Grenada. A small sugar-cane mill is now in course of erection in Grenada, for the use of allottees in the two settlements.

The outlines of the terms on which the sugar mill will be granted are of sufficient interest to warrant a short description. The total cost, about £300, will be repaid by an annual rental for ten years, of £25, and the sale of the mill for the outstanding balance plus interest and cost of repairs. The tenant must be an allottee on the settlements, and must pledge himself to handle canes on the 'metayer' system, that is retaining half the produce for his expenses and profits. Both tenants and growers have the right at any time to refer complaints to the Government through the Land Office or Agricultural Depart-

ment. Serious breaches of the contract or proved cases of dishonesty on the part of the tenant are punishable by cancelling of the contract without notice.

EXISTING MEASURES OF INSTRUCTION.

Up to the present instruction has been given in connexion with the Cacao Prize-holdings Scheme and the Land Settlements, by the Agricultural Instructor of the Agricultural Department.

THE INADEQUACY OF EXISTING MEASURES.

The actual expenditure on peasant control may be stated as follows:—

Recurrent:—

Prize-holdings, Grenada	£165
,, Carriacou	10
Prizes for Vegetables	12 10*s.*
Agricultural Instructor	200
	£387 10*s.*

Non-recurrent:—

Land Settlement, Carriacou	£6,250
,, ,, Grenada	5,000

The non-recurrent items do not represent actual expenditure, but merely advances which are later repaid: so that we may place the amount spent on peasant agriculture as £400 per annum, a sum which includes instruction and inducement.

SUGGESTIONS FOR THE FUTURE.

Briefly what are needed for the effective control of peasant agriculture are increased expenditure on instruction by the Government, a continuation and extension of existing measures of inducement, continuation and extension of measures of capitalization, and such modification of the Agricultural Department as will render it an effective instrument for carrying out the plans of the Government.

At the end of 1911, plans were submitted to the Agricultural Board for certain changes in the Agricultural Department which bear directly on the question under discussion. Briefly the proposals were that all matters relating to peasants should be treated by a separate division of the Department, and the division to be under the control of the Superintendent of Agriculture with the Agricultural Instructor as Officer-in-Charge. An additional clerk should be added to perform the clerical work and to keep accounts, and at the end of twelve months a second Agricultural Instructor should be added to the staff. The proposals are now (January 1912) being considered by the Board.

Such a division would have as its prime functions the following :—

(a) The keeping of systematic and up-to-date records of all peasant holdings in Grenada and Carriacou.

(b) Visiting peasants' holdings in the two islands, and the organization of regular peasant meetings on subjects of interest.

(c) The centralization of scattered agricultural activities, whereby local supply and demand would be more evenly balanced.

(d) The encouragement of new agricultural industries on hitherto unused lands.

(e) The improvement of existing methods of agriculture, the distribution of improved varieties of economic plants, and the effective control of plant diseases on peasants' holdings.

Since the year 1909, the matters more particularly concerned with peasants which have come within the scope of the Agricultural Department have been fairly numerous. First of all, must be mentioned the formation by the Government of a Land Office and its annexation to the Agricultural Department; and the appointment of a Land Officer with agricultural qualifications, and the entrustment by the Government to the combined Departments of the general control of the Grenada Land Settlements. Aid was lent by the Agricultural Department in the initiation of the Carriacou Prize-holdings Scheme. Besides these matters, the Department prepared plans for the erection of a cotton-ginning factory in Grenada, which is now completed, and also for a sugar-cane mill on the Grenada Land Settlement, which is now in course of erection. A plot to serve for experiments with, and distribution of, peasant crops has been started in Grenada, and a series of trials in the hybridization of maize and of cotton have been established. A good deal of useful work in importing new varieties of sugar-cane, tobacco, ground provisions, and in distributing them to peasants, has also been performed.

Were these the sole functions of the Agricultural Department, there would be little cause for complaint; but unfortunately, attention to the peasant questions of the Colony has, through inadequacy of the staff, led to neglect of other problems. The analytical work of the Department has been practically *nil*, and the larger problems of agriculture have had no attention.

In order to cope satisfactorily with the problems which have been raised merely by the activities of the Department mentioned above, and in addition to handle other proposals needing attention, there is a definite need for division of labour and increase of staff in the Department.

The cotton industry in Grenada is capable of development but careful work in selection and hybridization is necessary, needing part of the services of an officer with experiment plots at his command. The cultivation of maize needs improvement, and the types of this crop at present cultivated need selection, trial and hybridization. Classification of fruits and the breed-

ing of new varieties offer a large field for work. To mention but a few others, vegetables, bee-keeping, tobacco and small stock all need attention. Such questions of general control and organization as the establishment of loan banks, the instruction of peasants in rural industries, the provision on security, of manures to peasants, have all been discussed by the community, and the actual arrangements in detail form suitable work for an agricultural department.

To perform efficiently work of this nature and scope, a department would need three types of officers: (1) instructors, (2) experiment staff, (3) rangers.

At present the whole of the work is carried out by one Agricultural Instructor, while general control, the devising and actual conduct of experiments, and the consideration of all proposals form only part of the duties of the Superintendent of Agriculture.

There are several schemes whose settlement now looms in the near future, among which may be mentioned:—

(a) Attempts to dry, grind and sell the maize grown by peasants. This includes erection of buildings and machinery, formulation of satisfactory terms of purchase, the placing of contracts with merchants for the purchase of the products, and arrangements for efficient control of the plant and buildings.

(b) The initiation, encouragement and subsequent centralization of such rural industries as hat-making, broom-making and fruit-growing.

(c) The establishment and control of agricultural banks.

All these need not merely preliminary organization and actual inauguration, but continuous control and management.

It is a difficult matter to estimate the cost of supporting an efficient Government instrument, in the shape of an Agricultural Department, for the handling of the peasant question. Briefly for Grenada and Carriacou there would be needed two agricultural instructors, three or four temporary rangers employed for a couple of months each year, expert labourers for hat-making and broom-making, to whom apprentices would be attached, and the upkeep of three small experiment plots with resident rangers: clerical work could form part of the duties of the general department staff. A supernumerary officer whose duties would be chiefly confined to horticulture and plant-breeding might do valuable work.

In closing this paper it will be well to recall that attempts to increase the efficiency of agricultural methods among peasants in small tropical countries must invariably be expensive. Education, the ordinary incentive of competition, and ability to raise capital, are all reduced to a minimum and all need attention in any comprehensive scheme. The questions as to the advisability of control and help must certainly be answered in the affirmative from the ethical point of view, and probably also from the point of view of political economy.

[Pages 1 to 94, issued November 27, 1912.]

SUGAR-CANE EXPERIMENTS IN BRITISH GUIANA.

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PART I.

Accounts of the progress of the sugar-cane experiments in British Guiana have been prepared by one of us for submission at the Trinidad Agricultural Conference of 1905 and at the Barbados Agricultural Conference of 1908. The one now presented will carry on the general record of our work to the present time (January 1912). The three papers form concise records of the more generally interesting parts of the experimental work with sugar-cane in British Guiana from the year 1900.

As this is the only opportunity which the senior of us has had of describing in Trinidad the British Guiana field experiments, permission is sought to describe briefly the mode adopted by the Department of Science and Agriculture of British Guiana in laying out its experimental trials with sugar-cane and with other products, and the lines on which the results are considered.

The earliest series of extensive systematic field trials with sugar-cane in British Guiana which are on full record are those conducted by the Colonial Company during the eighties of the past century on several of their sugar-cane properties – Plantations Albion, Friends, Ma Retraite, and Mara, Berbice; Success, Peter's Hall, Vreed-en-Hoop, Demerara; and Hampton Court, Essequibo.

These were all arranged on the old supposition that in agricultural enquiries errors oft-repeated during a series of years may lead to accurate and reliable results; the experiments were conducted over comparatively large areas with $\frac{1}{2}$-acre plots and the unmanured plots intended to act as controls on each estate were in no instance duplicated. Hence no guidance was afforded to the well-marked variations in the fertility of the soils on each of the different series of plots which doubtless adversely affected the results of the trials and no guidance was afforded to the directions or extent of these soil differences. In the voluminous report issued, the results of no less than 858 applications of nitrogenous manures were detailed and of these 282 gave results lower than those yielded by the unmanured control plots. This illustrates most clearly the danger which everywhere underlies field-trials conducted on large areas especially where devoid of control over their very varying soil-conditions.

One of us had the advantage in 1879 of spending some time at Rothamsted and of there studying methods of agricultural research under the guidance of the late Sir John Bennet Lawes, F.R.S., and the late Sir Joseph Henry Gilbert, F.R.S. assisted by the late R. Warington, F.R.S., at that time the acknowledged leaders of the world in agricultural investigations and research and had for many years after, during the life-time of the two first-named masters, the advantage of consultation with them regarding the conduct and progress of his work.

The first years of the earlier experiments in Barbados which were started by Mr. J. R. Bovell, I.S.O., in 1885 in collaboration with one of us were directed to the determination of the lines of investigation suitable for the tropics and to ascertaining what checks were needful to ensure that the results should be fairly accurate and capable of being measured as to their probable degree of reliability. The first decision arrived at was given in the report of April 12, 1886, in the following words :—

'Bearing in mind the fact that the specific action of any manurial substance upon a crop or a soil can only be developed to its fullest extent or even to a sufficiently marked degree for its accurate study when the other necessary ingredients of plant food are present in relative excess, we propose to subdivide each series of experiments into three divisions (leaving in addition unmanured plots for comparison) to the plots on the first of which we shall apply phosphates and potash in the proportions which our experience has indicated to be in relative excess, and add to one plot none, and to the others gradually increasing amounts of the nitrogenous consti-

tuents. In the second and third we shall apply nitrogen and potash, and nitrogen and phosphates in relative excess respectively, adding to the second phosphates, and to the third potash in gradually increasing proportions.'

It was further realized that where the actions of the manures or of other agricultural processes were not great and not likely to be accentuated it was of importance that as many comparisons as feasible should be made. In the comparative trials with sulphate of ammonia and nitrate of soda in 1885 five duplicated plots were used, whilst in 1886 eleven duplicated plots with each substance were employed.

The necessity of having the unmanured control plots in more than duplicate was early realized. For instance, in the trials laid down in 1887 there were provided three control unmanured plots while in 1886 five unmanured control plots were laid down, and in 1888 four were employed.

In trials made in 1889 as to the effects of different distances for planting the deductions were drawn from six fields planted 5 feet × 5 feet and five fields planted 6 feet × 6 feet. These trials showed a 'probable error', on a single field comparison of 9·5 per cent. and one of 2·3 per cent. on the means of all the trials. The mean yield of canes on the fields planted 5 feet × 5 feet was 34·2 ± ·7 tons and that of the fields planted 6 feet × 6 feet was 27·8 ± ·6 tons hence the deduction was reliable and acceptable that under the conditions of the trials planting 5 feet × 5 feet was far more advantageous than planting 6 feet × 6 feet.

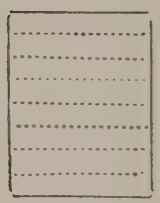
At the inception of the work in British Guiana advantage was taken of the experience gained in Barbados in planning out the trials. The first field brought under trial had an area of about 4½ Rhynland acres and was absolutely flat; as far as eye could tell every part of it was like every other part. It was divided into rows of plots so that seven plots are in sequence from east to west and thirteen plots in sequence from north to south. The plots in sequence from north to south are divided from each other by a not-cultivated path 1 rood (12·3 feet) in width. Those from east to west are divided into half-sections each $\frac{1}{50}$-acre in area, by 'two-foot' drains. Each plot is made up of two half-sections and is $\frac{1}{25}$-acre in area. The plan reproduced below will give a clear idea of the arrangement of the field :—

INDEX.

PLOTS.

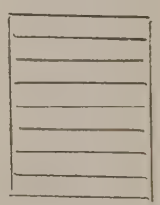
CONTROL PLOTS

10 NOT MANURED



CONTROL PLOTS

10 SIMILARLY MANURED



Paths between rows of plots

'2 foot' drains between plots

'2 foot' drains dividing plots in halves

Scale : $\frac{1}{6}''$ = 1 rood.

Drainage Trench.

NORTH DAM.

79	80	81	82	83	84	85	86	87	88	89	90	91
												EAST DAM.
6	12	18	24	30	36	42	48	54	60	66	72	78
5	11	17	23	29	35	41	47	53	59	65	71	77
4	10	16	22	28	34	40	46	52	58	64	70	76
3	9	15	21	27	33	39	45	51	57	63	69	75
2	8	14	20	26	32	38	44	50	56	62	68	74
1	7	13	19	25	31	37	43	49	55	61	67	73

SOUTH DAM.

WEST DAM.

Drainage Trench.

Ten plots irregularly distributed about the field were set apart as unmanured control plots and nine plots similarly distributed formed check-control plots, all being manured alike. The positions of the plots of the two series of controls are shown in the plan. The irregularity in the distribution of the plots was due to the necessities of the trials the land had to be used for. In two other fields, one with ninety-six plots and one with one hundred and forty-four plots, it has been found feasible for thirty-four and fifty-two plots respectively to be not-manured and for two series of plots to be similarly manured ; these control plots are symmetrically arranged over the whole areas of the fields.

During the first eight years of the experiments Bourbon was the only cane grown on the original field and no change was made in the systems of manurings employed.

Each experiment was made on triplicate plots and also was duplicated on the halves of the plots. In each series of plots every important experiment was repeated thrice by the manurial constituents under investigation being applied in proportions increasing in arithmetical progression. This enabled in each year of the trials numerous answers to be got to the questions under investigation as shown in the following :—

Questions.	No. of replies.
(1) Is nitrogen requisite in a sugar-cane manure?	48
(2) Is nitric nitrogen preferable to ammoniacal nitrogen?	24
(3) Is phosphoric acid requisite? ...	30
(4) Is potash of any use on this soil? ...	24

It is evident that the average of the replies to each of these multiplied questions must have a fairly high degree of accuracy, the soil-error inherent either in excess or deficit to any one of the questions if asked only of one plot being reduced in the following proportions :—

No. of question.	Single plot, 'Probable error' per cent.	Probable error per cent. on average of results.			
		1.	2.	3.	4.
1st crop	5·4	·8	1·1	1·0	1·1
2nd „	7·0	1·0	1·4	1·2	1·4
3rd „	6·0	·9	1·2	1 1	1·2
4th „	10·0	1·4	2·0	1·7	2·0
5th „	17·8	2·5	3·6	3·1	3·6
6th „	19·1	2·7	4·0	3·3	4·0

It was early recognized that there are modes of treatment the effects of which are not likely to be well-marked, so that the results may fall within the limits of the probable error if only a few plots are used for the investigation. To meet such cases advantage has been taken of the division of each plot into halves. For instance in the investigations into the action of lime on the fertility of the soil that substance was applied to the eastern half of each of the plots, thus its action was determined on ninety-one half-plots which were limed and the results compared with those obtained on the corresponding ninety-one half-plots which were not limed. In this way the limits of the probable error were reduced from 16·8 for a single trial to 1·8 for the mean of ninety-one trials.

Similar methods have been used for investigations into the action of phosphates on the fertility of the soil by which the limits of the probable error were reduced to less than 2 per cent., and into the action of molasses in which the limits are within 6 per cent. It is evident that the multiplication of trials results in a very greatly increased degree of reliability attaching to the deductions drawn from the experiments.

We desire to place on record that, prior to the application of the first manurings to the experimental field laid out in 1891, the plans of the field and the proposed arrangements of the plots and of their treatments were submitted by one of us personally to Sir John Lawes, F.R.S., and Sir Joseph Gilbert, F.R.S., and received their approval.

Two fields have since been laid out. One of them in 1901 with ninety-six $\frac{1}{50}$-acre plots, the other in 1909 with one hundred and forty-four $\frac{1}{70}$-acre plots.

The results which have been systematically recorded during the past twenty years on these specially laid out fields have supplied us with several extended series of figures by which we are able to calculate the 'probable errors' due to varying soil conditions which are incidental to field experiments with sugar-cane even when carried out under exceptionally favourable conditions as regards uniformity of soil and lay of the land. As mentioned earlier the field first laid out contained ten not-manured $\frac{1}{25}$-acre plots which are sub-divided into twenty not-manured $\frac{1}{50}$-acre plots and there were similar numbers of plots and half-plots which were uniformly manured. It also contained the following series of similarly manured plots :—

Numbers of plots.	Treatment.
(a) 2, 17, 26	Cinereals only
(b) 3, 16, 27, 79, 82 ...	Sulphate of ammonia 200 lb.
(c) 4, 15, 28	Cinereals and sulphate of ammonia 200 lb.
(d) 6, 13, 30, 86	Cinereals and sulphate of ammonia 400 lb.
(e) 7, 24, 31	Stable manure 20 tons
(f) 8, 23, 32	„ „ „ „ and 200 lb. sulphate of ammonia
(g) 9, 22, 33	Nitrate of soda 250 lb.
(h) 10, 21, 34	Cinereals and nitrate of soda 250 lb.
(i) 11, 20, 35	Cinereals and nitrate of soda 375 lb.
(j) 12, 36	„ „ „ „ „ 500 lb.
(k) 37, 39, 74, 88 ...	Ammonia, potash and 800 lb. mineral phosphates
(l) 43, 45, 68, 89	Ammonia potash and 500 lb. superphosphates
(m) 44, 67, 69	Ammonia and potash
(n) 49, 51, 62, 90 ...	Ammonia, potash and 400 lb. mineral phosphates
(o) 50, 61, 63, 91 ...	Ammonia, potash and 250 lb. superphosphates
(p) 53, 76, 78	Ammonia, superphosphate and 150 lb. sulphate of potash
(q) 58, 60, 71	Ammonia and superphosphate
(r) 59, 70, 72	Ammonia, superphosphate and 100 lb. sulphate of potash

From the results from these plots supplemented by the records of those of the field laid out in 1901, the following table of the 'probable errors' observed over areas of different sizes and plots varying in number from three to thirty-six for periods covering six crops has been drawn up:—

'Probable Errors' in Sugar-Cane Experiments, Experimental Fields, British Guiana, Crops of 1892-1908.

Areas, acres.	Numbers of plants on areas, rows 5 ft. apart.	Numbers of plants on areas, rows 6 ft. apart.	Probable errors of means of 1 plot.	2 plots.	3 plots.	6 plots.	9 plots.	16 plots.	25 plots.	36 plots.
·015	54-65	45-54	10·9	7·3	6·3	4·4	3·6	2·7	2·2	1·8
·02	72-86	60-72	8·4	6·0	4·8	3·4	2·8	2·1	1·7	1·4
·03	108-130	90-108	7·1	5·0	4·0	2·9	2·4	1·8		
·04	144-172	120-144	7·0	5·0	4·0	2·9	2·4	1·7	1·4	
·06	216-260	180-216	5·2	3·7	3·0	2·1	1·7			
·08	288-344	240-288	5·0	3·6	2·9	2·0	1·7			
·10	360-430	300-360	5·2	3·7	3·0	2·1	1·7			
·12	432-520	360-432	5·5	3·9	3·2	2·2				
·14	504-602	420-504	5·6	4·0	3·2	2·3				
·16	576-688	480-576	5·6	4·0	3·2	2·3				
·20	720-860	600-720	5·8	4·1	3·4	2·4				
·24	864-1,032	720-864	5·9	4·2	3·4	2·4				
·28	1,008-1,204	840-1,008	5·9	4·2	3·4					
·48	1,728-2,064	1,440-1,728	6·3	4·5	3·6					

The degree of uniformity or of accuracy in agricultural field experiments is not such as to require the use of Jevens' or Bissels' formulae for the calculation of the 'probable error' of a series of trials. The major part of the figures given in the table were calculated by these formulae. For all ordinary purposes

The table includes areas varying from $\frac{1}{66}$-acre to practically $\frac{1}{2}$-acre, and shows the number of cane-plants grown on them according to whether the cane-rows are 5 feet or are 6 feet apart.

The majority of the 'probable errors' recorded in the table are based on from two to six series of plots of each of the various sizes. The calculations were made on the results of the highest number of plots shown in each of the horizontal sections of the table. It will be observed that the liability to error is highest on plots of ·015 acre gradually becoming lower to plots of ·08 ($\frac{1}{12}$th) acre and from this minimum gradually increasing as the size of the plots becomes greater. The plots of areas of ·04 ($\frac{1}{25}$) acre and less are rectangular with their sides in the proportions of 3 to 2 or 3 to 4: plots from ·06 to ·10 acre are rectangular oblongs; whilst plots of areas of ·12 ($\frac{1}{8}$) acre and upwards are long and relatively narrow rectangular areas.

The table indicates that where five or six duplicate trials are made plots of from $\frac{1}{200}$-to $\frac{1}{100}$-acre in area are sufficiently large for all reasonable requirements, where nine or ten duplicate plots are used, areas of $\frac{1}{300}$-to $\frac{1}{200}$-acre are satisfactory, whilst should small plots of say $\frac{1}{400}$-to $\frac{1}{600}$-acre have to be used the treated and untreated plots must not be less than sixteen each in order that the mean results shall be reliable. Plots from $\frac{1}{200}$-to $\frac{1}{300}$-acre in area have been found by us, in the case of

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of agricultural research Peter's approximation formulae suffice. In these, if r is the probable error of the results of a single plot and R that of the arithmetical mean of the results from all the plots, S (+ v) is the sum of the deviations of every result from the arithmetical mean of all the results, and n the number of plots employed the formulae are:—

$$r = \pm 0{\cdot}8453 \frac{S\,(+\,v)}{\sqrt{n\,(n-1)}}$$

$$R = \pm 0{\cdot}8453 \frac{S\,(+\,v)}{n\sqrt{n-1}}$$

For practical purposes the factor 0·8453 may be taken as 0·85.

In non-mathematical terms the working of Peter's formula for the 'probable error' of a single plot-result is as follows;

(a) Determine the mean of the results of all the plots.

(b) Determine the deviations in excess or in deficit of every result from the mean as found by (a).

(c) Add together all the deviations irrespective of what is excess or deficit (i.e. disregarding the sign + or −).

(d) Multiply the number of plots by that number less one and find the square root of the product.

(e) Divide the sum found by (c) by the figure determined by (d).

(f) Multiply the quotient found in (e) by 0·85.

From the product of (f) as determined by the above process the 'probable error' of the mean result of the number of trials is obtainable by dividing the product by the square root of that number.

sugar-canes, to be the most suitable in size for ease and accuracy in the reaping of the produce.

Increased accuracy has not been obtained in the sugar-cane trials by increasing the area of the plots beyond $\frac{1}{12}$-acre each. Not only are portions of the larger plots situated much farther apart than are the parts of closely adjacent small plots but the larger plots are more likely to have more or lest pronounced irregularities of soil in them than are present in smaller ones. The difficulty of getting the various cultural and reaping operations carried through on several large-sized plots in the same day introduces a source of error that is readily eliminated from or not present in the smaller ones.

Effects of Different Seasons on the Probable Error.

The unavoidable errors have been lowest in favourable years and highest in years in which meteorological conditions and the onset of disease in the canes have proved more or less disastrous to their yields. This is shown by the following tables. The first of these, No. I, was drawn up in 1905 from the field results with Bourbon canes on the half plots of $\frac{1}{30}$-acre during the crops of 1892 to 1904 whilst the second, No. II, has been calculated later from the results of two series of similarly treated $\frac{1}{25}$-acre plots during the crops of 1892 to 1902.

No. I.

CROPS OF 1892-1904, $\frac{1}{50}$-ACRE PLOTS.

Years.	No. of duplicate plots.	'Probable error' excess or deficit per cent. of mean of all plots.	
		All plots.	Two plots.
1892	26	1·6	8·0
1893	26	1·7	8·5
1894	26	3·0	15·0
1895	26	3·2	16·0
1897	10	6·3	18·9
1898	10	10·5	31·5
1899	Canes	practically died out.	
1900	10	6·6	19·8
1902	10	4·6	13·8
1903	8	3·7	7·5
1904	8	3·9	8·0

No. II.

CROPS OF 1892-1902, $\frac{1}{25}$-ACRE PLOTS.

Years.	No. of duplicate plots.	'Probable error' excess or deficit per cent. of mean of all plots.	
		All plots.	Two plots.
1892	9	1·8	3·8
1893	„	2·7	5·0
1894	„	2·0	4·3
1895	„	3·3	7·1
1897	„	5·9	12·7
1898	„	6·2	13·6
1900	7	1·8	4·8
1902	„	2·3	6·0

The above tables cover the period during which extensive trials were carried on with the Bourbon cane. It became impossible to get satisfactory results with that variety about the years 1902-4 and hence it was no longer feasible to continue to occupy numerous plots with canes of that variety. These tables show that during the first two years and the last two years of the trials which years were favourable to sugar-cane cultivation the probable error attaching to the mean results of two duplicate-plots of $\frac{1}{50}$-acre each was about 8 per cent. of the mean yields of all the control plots, while on plots of $\frac{1}{25}$-acre the probable error attaching to the mean results of two duplicate plots during the first three years and the last two years of the period 1892-1902 varied from 3·8 to 6 per cent. of the mean yields of all the control plots.

It is frequently held that by making the trial-plots larger and extending the experiments over several years the effects of the unavoidable errors other than meteorological ones tend to counterbalance one another. This has not been so in our trials. Our records show that for areas of approximately $\frac{1}{2}$-acre each the variations from their means taken as 100 in a crop or a period of crops have been as follows :—

Period.	A. B. C. Mean yield.	Yields of			Range of variation per cent.
		A.	B.	C.	
1st crop ...	100	106·3	96·1	96·5	10·29
3 crops ...	„	109·6	89·0	100·9	20·6
6 crops ...	„	91·1	100·4	103·0	12·9

The range of variation in the means of the results of three and of six crops were greater than were those of the first crop. Results showing that the range of variation is not lessened by repetition of the trials have been recorded from areas of about $\frac{1}{7}$-acre and $\frac{1}{5}$-acre each. They are as follows :—

Period.	D. E. F. Mean yield.	D.	Yields of E. [$\frac{1}{7}$-acre.]	F.	Range of variation per cent.
1st crop ...	100	107·0	100·8	92·4	14·6
3 crops ...	,,	104·9	103·4	92·2	12·7
6 crops ...	,,	107·0	102·4	92·7	14·3

Period.	G. H. I. Mean yield.	G.	Yields of H. [$\frac{1}{5}$-acre.]	I.	Range of variation per cent.
1st crop ...	100	100·4	99·7	100·4	0·7
3 crops ...	,,	92·5	97·6	100·5	8·0
6 crops ...	,,	91·2	100 5	108·4	17·2

Similarly on smaller areas the variation of the single period from the means of the results of six plots have been :—

Period.	$\frac{1}{10}$-acre.	$\frac{1}{14}$-acre.
1st crop	2·8	21·7
3 crops	17·7	23·2
6 crops	18·9	18·3

It is thus evident that in a series of trials on exceptionally favoured land for such work the soil errors are not smoothed out by extending the experiments over six crops, a period of eight years.

This conclusion is fully confirmed by studies of the results obtained on the plots and series of plots of the field laid out in 1901.

These conclusions as to the probable errors incidental to cultural experiments in the tropics have been arrived at by our studies with plants not having marked individuality and, as a glance at the table of probable errors will show, using large to very large numbers of such plants. If the method of agricultural experiments and enquiries using relatively large single plots is unsatisfactory and unreliable with a plant such as the sugar-cane, it must be far less reliable, even in some

cases to the extent of being misleading, with permanent crops such as cacao, coffee, coco-nuts, etc. This has been demonstrated to be the case with cacao in our work at Onderneeming School farm reported on pages 351 to 355 of the *West Indian Bulletin*, Vol. XII, No. 3, for 1912.

Under the usual conditions of agricultural investigations the multiplication of large plots is not feasible. With four series each of nine duplicated plots of $\frac{1}{25}$-acre each and with a similar number of $\frac{1}{50}$-acre plots we found the probable errors of their mean results to be as follows :—

Periods.	$\frac{1}{25}$-acre.	$\frac{1}{50}$-acre.
1st crop ...	1·8	2·2
2nd „	2·6	2·7
3rd „	2·0	2·6
4th „	3·4	3·9
5th „	6·9	7·5
6th „	6·4	10·4

It is evident from the above that the results indicated by the means of the yields of nine plots of small area in any year in which the meteorological conditions were at all favourable have been reliable for the study of the problems we have had to enquire into. Even in unfavourable years the results have been sufficiently well-marked and reliable on plots of $\frac{1}{25}$-acre to enable deductions to be drawn when the differences were of greater magnitude than about 14 per cent. of the mean yields of the control plots.

Owing to the great range of variation in the yields of agricultural products due to the varying meteorological conditions of different years, to the greater or less prevalence of insect pests and to the occasional onsets of plant diseases it has not proved feasible in our work to determine the degree of accuracy by which the yields of a variety of a plant during one crop may approximate to the mean yields of several successive crops. But the test of the determination of 'probable errors' can be applied when comparing the yields of a variety over a series of crops with those of a standard variety and it will be so employed in later parts of this paper.

The following table covering the crop-years 1892 to 1904 well illustrates the very wide range of the yields of sugar-canes per acre as governed by the varying meteorological conditions during their periods of active growth and the dependence of the value of the 'probable errors' and 'possible errors' of the results of the trials in each crop on these conditions :—

Crops of 1892 to 1904, inclusive.

Bourbon Canes.

Crops.	Export of sugar, tons.	Experimental Fields $\frac{1}{50}$-acre plots.							
		Plants or ratoons 11-12 months old.	Rainfall in inches, previous 12 months.	Mean yields of canes, tons per acre.	No. of duplicate plots used.	Excess or deficit, per cent. of the mean yields of all plots used.			
						Probable errors.		Possible errors, single plots results.	
						All plots.	Two plots.	Calculated.	Actual.
November.									
1892	112,880	Plants*	167·5	50·9	26	1·6	8·0	12·8	14·2
1893	107,771	Ratoons, 1st	124·4	30·8	26	1·7	8·5	13·6	18 7
1894	102,502	,, 2nd	99·3	22·6	26	3·0	15·0	24·0	21·4
1895	101,059	,, 3rd	84·4	18·3	26	3·2	16·0	25·6	23·8
1897	108,839	Plants	96·7	15·4	10	6·3	18·9	50·3	54·6
1898	96,648	Ratoons, 1st	111·9	6·6	10	10·5	31·5	83·8	93·7
1899	84,783	,, 2nd	69·3	Canes p	ractically	died out			
1900	94,745	Plants	75·5	12·3	10	6·6	19·8	53·5	37·0
April.									
1902	105,694	Ratoons, 1st**	125·7	20·3	10	4·6	13·8	37·3	26·0
1903	120,127	,, 2nd	87·1	14·1	8	3·7	7·5	20·0	21·0
1904	125,949	,, 3rd	107·8	8·8	8	3·9	8·0	21·3	23·0

* 17 months.
** 15 months.

PART II.

The Composition of the Soil-Water as Affected by Cultivation and Manuring of the Soil.

On pages 22 to 37 of Volume IX of the *West Indian Bulletin* will be found an account of certain studies on the soil waters in cane and rice fields in British Guiana. From time to time these studies have been continued.

During the dry season of 1908 examinations were made of samples taken at weekly intervals from the ground water at the experimental fields. The results were as follows :—

Description of soil waters.				Contents in milligrammes per litre.					
No. of sample.	Date when dug, 1908.	Depth of water table, ft. in.	Rainfall in inches, previous week.	Chlorine.	Carbonates as calcium carbonate.	Nitrogen in			Total nitrogen.
						ammonia.	nitrates.	organic matter.	
1	Sept. 28	3 9	Nil	4,425	975	Nil	·204	·527	·731
2	Oct. 5	3 6	·47	3,787	900	Trace	·270	·446	·716
3	„ 12	3 8	2·33	3,752	880	Nil	·191	·379	·570
4	„ 20	3 9	Nil	4,071	950	„	·665	·066	·731
5	„ 26	3 0	·63	3,823	1,040	Trace	·455	·263	·718
6	Nov. 2	Sample spoilt							
7	„ 9	3 0	3·38	3,221	995	Trace	·441	·066	·507
8	„ 16	3 8	·24	3,150	990	„	·356	·214	·570
9	„ 23	3 8	1·22	3,681	1,045	„	·181	·082	·263
10	Dec. 1	2 11	·36	4,743	1,020	Nil	·296	·222	·518
11	„ 7	3 4	1·14	4,106	975	·007	·553	·065	·625
12	„ 15	1 6	5·95	3,080	915	Nil	·573	·066	·619
13	„ 24	1 8	2·46	2,832	955	·329	·066	·221	·616

The above results confirm those reported in Volume IX of the *West Indian Bulletin* as to the almost complete absence during the dry season of nitrogen in the form of ammonia and the constant presence in relatively high proportions of nitrogen in the form of nitrates. A considerable quantity of nitrogen is always present in the water as nitrogenous organic matters.

The alkalinity and the mean contents of chlorine and of the various forms of nitrogen in the waters collected during the dry season and after the rainy season had well set in were as follows :—

Contents in milligrammes per litre

Alkalinity as calcium carbonate.	Chlorine.	Ammonium.	Nitrate ion.	Nitrogen in organic matter.	Total nitrogen.
971	3,804	·00081	1·687	·2178	·5473
940	3,184	·4654	·569	·2425	·633

It appears from these and from results recorded in the *West Indian Bulletin* (loc. cit.) that the onset of the rains is marked by great changes in the state of combination of the nitrogen in the soil waters. It is evident that during the dry season nitrification is active and that when the soil becomes saturated with water much of the nitric nitrogen is reconverted into ammoniacal nitrogen.

The clay soils of the Experimental Fields are, at a depth of from 8 to 9 feet from the surface, underlain by a layer of very fine-grained argillaceous sand locally called 'Caddy'. It appeared desirable to determine the nature of the water in this sand and the following results were recorded :—

Contents in milligrammes per litre.

Alkalinity as calcium carbonate.	Chlorine.	Ammonium.	Nitrate ion.	Nitrogen in organic matters.	Total nitrogen.
1,235	4,237	1·0504	·6677	1·587	2·555

This is of interest in showing that the water in the deeper non-aerated part of the subsoil contains relatively high proportions of nitrogen as ammonia and in organic nitrogenous matters but very low proportions as nitrates.

The soil on the part of the field from which these samples were taken has always yielded unsatisfactorily and is of low fertility. Analyses were made of water collected from its clay subsoil at a depth of from 3 to 6 feet and of the water yielded by the underlying sand beds. The results were as follows :—

Contents in milligrammes per litre.

	Water from clay 3 to 6 feet.	Water from sand 8 to 12 feet.
Chlorine	3,502	4,237
Sulphate ion	203	56
Carbonate ion	610	784
Nitrate ion	·84	·67
Phosphate ion	1·26	1·04
Silica	40	36
Calcium	84	69
Magnesium	333	332
Potassium	85	106
Sodium	2,086	2,623
Ammonium	·395	1·05
Nitrogen in organic matter	·264	1·587
Equal to total nitrogen	·850	2·555

These waters mainly differed from those obtained from the more fertile fields in their relative proportions of magnesium to calcium, their molecular ratios being :—

		Calcium.	Magnesium.
Not fertile	Water from clay	1	6·60
	Water from sand beds	1	7·08
Fertile	Water from clay	1	2·83
	Water from sand beds	1	8·15

Another point noticed was the low percentage of the sulphate ion in the deeper waters as compared with that in the shallower ones.

Towards the end of 1909 the compositions of the waters underlying the more fertile fields were ascertained. The results obtained were as follows :—

Contents in milligrammes per litre.

	Water from clay $6\frac{1}{2}$ ft.	Water from sand $9\frac{1}{2}$ ft.	Water from sand $12\frac{1}{2}$ ft.
Chlorine	3,334	3,866	4,682
Sulphate ion	226	71	18
Carbonate ion	778	995	1,010
Nitrate ion	·434	·0945	·868
Phosphate ion	·6	·5	·2
Silica	33·	59	53
Calcium	82	74	73
Magnesium	318	324	357
Potassium	46	74	74
Sodium	2,164	2,605	3,053
Ammonium	·0049	·0586	·0327
Nitrogen in organic matters	·196	·220	·2746
Total nitrogen ...	·2978	·2870	·5033

The molecular ratios of calcium to magnesium are :—

	Calcium.	Magnesium.
Water from clay, $6\frac{1}{2}$ feet ...	1	6·46
Water from sand, $9\frac{1}{2}$ feet ...	1	7·29
Water from sand, $12\frac{1}{2}$ feet ...	1	8·15

We now have the following comparisons :—

	Calcium.	Magnesium.
1. S.E. field, fertile (limed in part in 1891)	1	2·40
2. N.E. field, fertile (not limed) ...	1	3·26
3. N.E. field, deep-seated water, $12\frac{1}{2}$ ft.	1	8·15
4. S.W. field, not fertile	1	6·60
5. S.W. field, not fertile, deep-seated water	1	7·08

It is evident that the soil waters from the not-fertile field have far higher ratios of magnesium to calcium than characterize the soil waters of the fertile fields. It is possible that the defective fertility of the field is, in part at any rate, due to an abnormally low content of readily soluble lime in the upper layers of its soil and to test this the fields will be dressed with lime.

The decrease in the proportions of sulphates as the depth from which the waters were obtained increased is evident. It is due to the sulphates in the alkaline water undergoing deoxidation in the deeper layers of the soil, the sulphur being deposited as free sulphur or as sulphide of iron in the dark-coloured argillaceous sand.

The proportions of the ions found in the shallow waters and in the deep waters when the chlorine is taken as 100 compared with those present in normal sea-water calculated on a like basis are as follows :—

	Means.		Sea-water.
	Shallow sub-soil waters.	Deep sub-soil waters.	
Chlorine	100	100	100
Sulphate ion	24·4	1·2	13·8
Carbonate ion	11·4	18·2	·4
Calcium ion	6·0	1·7	2·1
Magnesium	6·6	8·0	6·7
Potassium	1·2	2·2	2·0
Sodium	65·2	66·2	55·3

It is evident that the deep waters correspond more closely in composition with diluted sea-water than do the shallower subsoil waters. The differences in the shallower waters are such as would be expected from the changes which the water would undergo and the additions it would receive during its passage through the upper soil to the lower more or less impervious layers which lie between the subsoils and soils of the fields, and the water-bearing sands.

It was considered of interest to endeavour to detect in the waters from the upper layers constituents which occur in earths and soils in exceedingly low proportions. Several gallons of the soil waters were concentrated to the crystallization stage, the major portion of the sodium chloride and other less soluble constituents separated from the mother-liquor; much of the remaining sodium and potassium chlorides was thrown out by saturating the mother-liquor with hydrochloric

acid gas; the residue from the slightly acid mother-liquor was separated from the deposited salts, evaporated to dryness and treated with absolute alcohol. The portion which dissolved in the alcohol was separated by evaporation, dried, and again treated with absolute alcohol. By repetition of this treatment a residue of a few milligrammes in weight nearly free from sodium and potassium salts was obtained in which the presence of lithium was readily proved both chemically and spectroscopically, whilst spectroscopic examination proved the presence of traces of rubidium.

The clay-soil of these fields as removed from the fields just below the water-table was found to contain 42·8 per cent. of water. In this condition its specific gravity was 1·57, and its weight per cubic foot was 98 lb., so that the weight of an English acre of the soil one foot in thickness is about 4,273,000 lb. whilst that of a Rhynland acre is 4,486,000 lb.

Using the figures determined in 1907-8, which were published on pages 24, 25, and 26 of the *West Indian Bulletin*, Vol. IX, the following are the weights in pounds of the solid constituents of the water present in an English acre-foot of the soil :—

	Old cane field.			
	Not cultivated.	Cultivated, not manured.	Cultivated and manured.	Cultivated but not fertile.
Chlorine	7,767	5,957	5,745	6,450
Sulphate ion ...	1,130	1,116	1,093	374
Carbonate ion ...	987	612	891	1,124
Nitrate ion ...	2·3	3·2	2·6	1·5
Phosphate ion ...	1·6	1·6	2·6	2·3
Silica	88	68	65	73
Calcium	355	429	595	155
Magnesium ...	553	617	403	613
Potassium	198	118	53	156
Sodium	4,830	3,210	3,505	3,842
Total nitrogen ...	9·3	11·4	9·9	15·6

New cane field.

	Not cultivated.	Cultivated, not manured.	Cultivated and manured.
Chlorine	6,100	6,560	6,000
Sulphate ion ...	1,655	1,150	1,105
Carbonate ion ...	672	894	744
Nitrate ion ...	1·7	1·3	1·4
Phosphate ion ...	trace	trace	·7
Silica	60	65	59
Calcium	440	368	337
Magnesium ...	525	731	644
Potassium	55	92	84
Sodium	3,810	3,678	3,482
Total nitrogen ...	7·8	9·7	13·4

Assuming that the argillaceous sand or 'caddy' underlying the clay soil contained a similar proportion of water to that found in the clay, its contents in pounds per acre-foot will be as follows :—

	Old cane field.	New cane field.
Chlorine	7,784	7,784
Sulphate ion ...	102	83
Carbonate ion ...	1,335	1,788
Nitrate ion	2·9	·9
Phosphate ion ..	1·9	·6
Silica	66	103
Calcium	127	136
Magnesium	610	627
Potassium	194	136
Sodium	4,818	5,218
Total nitrogen ...	46·9	7·3

These figures give some idea of the relatively enormous quantities of soluble salts, some of which are practically useless as plant foods whilst others are more or less inimical to plant growth, present in the lower layer of the soil and in the subsoil of the Experimental Fields.

From these data and the results of the analyses of the various waters the quantities of the saline constituents of the soil water as conventionally combined may be estimated as follows :—

	3-8 feet, lb. per acre.	8-12 feet, lb. per acre.	Total 3-12 feet, lb. per acre.
Old cane field, fertile section.			
Calcium carbonate ...	5,750	1,260	7,010
Magnesium carbonate	970	6,750	7,740
Magnesium sulphate ...	6,960	500	7,460
Magnesium chloride ...	3,520	1,490	5,010
Potassium chloride ...	1,140	1,490	2,630
Sodium chloride ...	48,120	48,380	96,500
Old cane field, not fertile section.			
Calcium carbonate ..	1,940	1,260	3,200
Magnesium carbonate ...	6,250	6,750	13,000
Magnesium sulphate ...	2,340	500	2,840
Magnesium chloride ...	3,210	1,490	4,700
Potassium chloride ...	1,490	1,490	2,980
Sodium chloride ...	47,080	43,380	95,460
New cane field.			
Calcium carbonate ...	4,770	1,360	6,130
Magnesium carbonate ...	1,380	8,150	9,530
Magnesium sulphate ...	8,130	420	8,550
Magnesium chloride ...	4,270		4,270
Potassium chloride ...	710	1,040	1,750
Sodium carbonate ...		870	870
Sodium chloride ...	45,760	51,200	96,960

Thesoil waters in the fertile parts to a depth of 12 feet from thesurface contain in one acre about 43 tons of sodium chloride common salt), $3\frac{4}{5}$ tons of magnesium carbonate, $3\frac{1}{5}$ tons of magnesium sulphate, 2 tons of magnesium chloride, 1 ton of potassium chloride, 4 cwt. of sodium carbonate and nearly 3 tons of calcium carbonate.

On the non-productive section the quantities of sodium chloride and potassium chloride are similar in amount to those on the fertile parts, but the total magnesium salts which are a little less than in the fertile land—9 tons as compared with 9·3 tons—contain, in round figures 6 tons of magnesium carbonate in place of $3\frac{4}{5}$ tons, whilst only about half as much ($1\frac{2}{5}$ tons) of calcium carbonate is present in it as there is in the fertile land.

The soil water brought to the upper layers of the soil during periods of prolonged dry weather may evaporate under two conditions, the first existent in the upper layer of soils either naturally deficient in organic or humus matters or rendered so by injudicious cultivation where the evaporation takes place into air containing relatively little carbonic acid gas; the second existent in the upper layers of soils rich in organic or humus matters, where the evaporation takes place into air surcharged with carbonic acid gas produced by the gradual oxidation of the carbonaceous organic matters.

Two series of trials were arranged, in the first of which soil water was allowed to evaporate into the air, while in the second it was caused to evaporate into an atmosphere consisting almost entirely of carbonic anhydride.

During the evaporation of the sample exposed to free air, after the lapse of nearly seven weeks small colourless spherules were deposited which on examination were found to consist mainly of calcium carbonate in the form of arragonite. Analysis showed that the spherules were composed of 91 per cent. of calcium carbonate and 9 per cent of magnesium carbonate. Analysis of the liquid remaining—which now was reduced to one-third of its original bulk—showed that it contained little lime in solution. During the ensuing six weeks the water deposited a flocculent substance which consisted of hydrated magnesium carbonate with some calcium sulphate and a very little calcium carbonate. After dehydration, 100 parts of this substance was found to consist of:—

Calcium sulphate	·36
Calcium carbonate	·08
Magnesium carbonate	99·56

At this stage it was found that the liquid remaining contained 34,309 parts of chlorine per million as compared with 3,710 parts in the water when first submitted to evaporation, its concentration by evaporation being therefore to one-ninth of its original bulk. The concentrated liquid was found to be practically free from calcium salts.

During the next fortnight the liquid became concentrated to a little less than $\frac{1}{21}$ of its original bulk and contained

chlorine at the rate of 80,000 parts per million. During this period it deposited small quantities of hydrated magnesium carbonate. For two weeks longer the evaporation continued, the liquid depositing crystals principally of sodium chloride with a little magnesium sulphate and some amorphous silica. When the evaporation was completed the solid constituents of the small quantity of mother-liquor left had the following composition in milligrammes per litre of the liquid :—

Chlorine	152,918
Sulphate ion	35,523
Carbonate ion	1,024
Calcium	30
Magnesium	20,231
Potassium	10,842
Sodium	77,468

It is not possible to state positively the state of combination of the constituent elements in the original water nor in the water whilst it is undergoing concentration by evaporation. But advantage was taken of the fact that the double carbonate of magnesium and sodium which is soluble in water is nearly insoluble in alcohol saturated with carbonic acid to estimate the proportions of this substance that might be present in the water during its gradual concentration by evaporation in free air.

Samples of 25 c.c. each of the water were taken, cooled to about 10° C. and saturated with carbonic acid gas. Absolute alcohol was similarly saturated with the gas, and mixed with the water until it ceased to produce a flocculent precipitate, the mixture being kept at a temperature of about 10° C. The precipitate was separated by filtration from the liquid and washed repeatedly with absolute alcohol saturated with carbonic acid gas. When free from adherent salts the precipitate was treated with water in which it was readily dissolved, and was titrated with standard acid to determine its degree of alkalinity. Qualitative analysis of the precipitate showed it to consist of a double carbonate of magnesium and sodium. Sufficient of the precipitate was not obtained to enable its composition to be determined quantitively.

The following tables show the effects of the gradual evaporation of the soil water on its contents of chlorine, and on its degrees in terms of calcium carbonate of total alkalinity, permanent alkalinity, and the alkalinity of the precipitate obtained from it as above described :—

Contents in milligrammes per litre.

Date when sample was examined.	Chlorine.	Total alkalinity.	Permanent alkalinity.	Alkalinity of precipitate by alcohol.
June 1 ...	3,710	763	423	not determined
July 17 ...	11,285	1,820	1,260	1,140
August 1 ...	17,557	2,000	1,750	1,870
August 30 ...	34,309	1,750	1,700	1,650
September 15 ...	80,000	1,200	1,100	1,100
October 1 ...	152,918	1,700	1,700	not determined

Chlorine taken as 100.

June 1 ...	100	20·6	11·5	not determined
July 17 ...		16·1	11·2	10·1
August 1 ...		11·4	10·0	10·6
August 30 ...		5·1	5·0	4·8
September 15 ...		1·5	1·4	1·4
October 1 ...		1·1	1·1	not determined

These figures show the rapid decrease of the total alkalinity due to the early deposition of the calcium carbonate and the gradual decrease of the permanent alkalinity—alkalinity not removable by boiling without reduction of volume by evaporation—during the later stages of the evaporation by the depositions of magnesium carbonate. They also indicate that, if present, the double carbonate of sodium and magnesium is not permanent during concentration by evaporation in the presence of excess of salts of magnesium such as the chlorides and sulphates.

The water which was evaporated in an atmosphere of carbonic acid gas contained at the commencement of the evaporation 3,767 parts of chlorine per million by volume. It evaporated steadily without depositing any of its constituents for eight weeks when a few spherules of arragonite were deposited. It then contained 65,080 parts of chlorine per million having become concentrated to about one-seventeenth of its original bulk. Depositions of a mixture of minute spherules of arragonite, scales of hydrated magnesium carbonate, specks of silica and abundance of crystals of sodium chloride, with some of magnesium sulphate and potassium

chloride took place during the next seven days at the end of which it had become practically a crystalline paste with a little mother-liquor. The mother-liquor contained 154,000 parts of chlorine per million and the composition of its solid constituents in milligrammes per litre of the liquid was :—

Chlorine	154,900
Sulphate ion	28,967
Carbonate ion	4,604
Calcium	23
Magnesium	13,105
Potassium	926
Sodium	92,400

The course of the evaporation in the carbonic acid gas is shown by the following analytical determinations :—

Contents in milligrammes per litre.

Date when sample was examined.	Chlorine.	Total alkalinity.	Permanent alkalinity.
July 24	3,767	800	450
September 3	6,367	1,350	775
October 20	50,800	10,860	6,400
October 24	65,000	8,400	4,000
October 30	154,000	7,680	5,810

Chlorine taken as 100.

July 4	100	21·2	11·9
September 3		21·2	12·1
October 20		21·1	12·4
October 24		13·0	6·3
October 30		5·1	3·8

These show that the alkalinity, whether total or permanent, was not affected during the early stages of the evaporation and remained constant until calcium carbonate commenced to be deposited, and that later both decreased the total alkalinity somewhat more rapidly than the permanent alkalinity.

The important points in connection with the evaporation in air and in carbonic acid gas, are as follows :—

Where the evaporation takes place in air nearly free from carbonic acid gas, practically the whole of the calcium salts are deposited as calcium carbonate whilst the water is being concentrated to about one-third of its original bulk, and the remaining water becoming a highly saline one containing large proportions of magnesium salts—the chloride, sulphate and carbonate—in solution. The calcium salts, which are well known to exercise a profound influence in reducing the highly toxic action of the magnesium chloride and carbonate on plants, are almost completely removed from solution and the soil water becomes in a condition poisonous to vegetation. This is what probably takes place during periods of prolonged dry weather on more or less worn-out sugar-cane soils in which by injudicious cultivation and especially by long-continued destruction of the trash by burning the normal proportions of organic matter have been largely reduced. Where, on the other hand, the evaporation takes place in an atmosphere heavily charged with carbonic acid gas as is the air present in soils containing the proportions of organic matters normal to good soils the lime-salts remain in solution until the liquid commences to become a saturated brine and thus for a prolonged period continue to modify the toxic action of the magnesium salts. It is possible on such land that the soil water during droughts may become concentrated in the upper layer of the soil without very material injury to the plants until by concentration of the soil-water the toxic action of the sodium chloride exerts itself.

These trials therefore, accentuate the importance of the conservation and, where feasible, the increase of the organic matters present in tropical soils, a point which is far too often overlooked by intensive cultivators of tropical products. The investigation further accentuated the importance of the addition of more or less soluble salts of lime—the nitrate, sulphate or 'superphosphate' to soils containing excesses of soluble or actively poisonous salts of magnesium.

Many trials have been made on the cane fields of British Guiana with the cultivation of leguminous plants as fallow crops. All have been financial failures. In the majority of cases the costs of cultivation and of turning in the green dressing have proved to be higher than the value of the increased crops obtained by the amelioration of the soil by the fallow crops. In others the leguminous crops either failed entirely to grow or their growth was cut short by drought or by excessive rainfall. In others again, as recently on the Experimental Fields, it was found that the legumes would not grow on the land immediately after sugar-canes were taken off it, although after a period of naked fallowing or of leaving the land to its natural fallow crops of weeds of many kinds the legumes grew luxuriantly.

It has been noticed, probably first very many years ago by bygone races of planters, that land long under cane cultivation and apparently in a state of temporary agricultural exhaustion if flooded with water and left in that state for some

months or even a year or two where the water was drained off and the land replanted sugar-canes grew on it with great vigour and gave a succession of heavy crops. This practice has been steadily becoming more in vogue since 1894 when the Hon. R. G. Duncan employed it more or less successfully on Pln. Windsor Forest as a means of combating rind and root diseases of sugar-cane. It is difficult to fully explain its action.

In the hope of being assisted to such explanation Mr. F. I. Scard and one of us brought the question before a committee of the technical chemists who were members of the Agricultural Conference of 1900. Some of that committee, it is to be feared, thought that the British Guiana representatives were in humorous mood in submitting such a problem. But our recent enquiries have tended to elucidate one phase of the question. It is very probable that the vast quantities of water, frequently purely rain-water, used for flooding the fields take up from the lower layers of the soil and the upper parts of the subsoil large quantities of the injuriously concentrated soil waters, thus lessening the degree of alkalinity of the clays and reducing the proportion of sodium and magnesium salts which are present in the parts of the soil which form the support of plants.

The following determinations of the nature of the subsoil waters on the rice and rubber fields illustrate the reduction of the humus constituents, of the chlorine, and of the alkalinity of the soil waters by putting the land under water :—

Contents in milligrammes per litre.

Treatment of land.	Humus.	Chlorine.	Alkalinity in terms of calcium carbonate.
Never irrigated	575·4	4,818	1,415
Irrigated for rice 1907-11 (about 10 weeks in each year)	86·3	3,360	800

These samples were collected in February 1912 after many months' drought and four months after the irrigation-water had been run off from the land. An earlier comparison made in 1907 a few weeks after the irrigation-water was run off resulted as follows :—

Contents in milligrammes per litre.

	Never irrigated.	Irrigated 1903-7 (18 weeks in each year).
Chlorine	7,700	2,400
Sulphate ion	1,428	792
Carbonate ion	542	416
Iron	66	–
Calcium	114	120
Magnesium	894	260
Potassium	46	30
Sodium	4,244	1,677
Ammonium	0·019	0·381
Nitrate ion	0·038	0·366
Total nitrogen	0·027	0·443
Alkalinity in terms of calcium carbonate	902	693

As a sequence of our investigations it is now a somewhat-common procedure for the Agricultural Chemists on sugar-estates in British Guiana to examine the soil waters of the fields and to, in part at least, base their advice as to the treat ment of the soils on the results of such examination.

PART III.

The Manuring of the sugar-cane.

Our investigations have been continued into this important question. Our earlier trials proved to almost mathematical demonstration that the yields of sugar-cane are dependent on the amount of readily available nitrogen either naturally present in the soil or added in manure. At first these principles applied only to the Bourbon cane, but during the past ten years they have been found by us to apply practically to every variety of sugar-cane we have tried with nitrogenous manures. The following tables show the results of these trials in which sulphate of ammonia was used as the source of nitrogen :—

Series I.

Tons of canes per acre.

Varieties.	No. of crops.	No nitrogen.	Low nitrogen, 40 lb. per acre.	High nitrogen, 80 lb. per acre.
Bourbon	15	13·6	18·2	23·1
D. 145	10	17·5	24·0	30·6
D. 625	9	27·2	34·4	36·7
White Transparent ...	8	18·6	24·6	27·6
D. 109	7	23·6	27·2	33·3
B. 147	6	19·7	25·8	30·4
D. 116	6	29 0	33·5	38·2
D. 3956	6	29·4	35·0	39·7
D. 4397	5	19·7	22 8	27·1
D. 78	5	21·1	28·2	33·6
B. 208	4	14·1	17·4	23·5
D. 2468	4	11·1	18·3	27·1
Sealy	3	17·3	24·8	27·6
D. 2190	3	17·9	21·1	28·0
D. 1087	3	14·9	20·7	30·4
D. 433	3	12·9	24·0	27·7
D. 4407	3	10·7	18·8	22·7
D. 177	3	14·8	22·8	25·2
D. 298	3	18·0	25·0	25·5
D. 4	2	14·9	21·6	23·9
D. 99	2	8·0	10·9	17·5
D. 366	2	14·0	16·1	24·8
D. 14	2	14·1	20·5	23·1
D. 13	2	11·3	17·0	18·2
D. 24	2	16·1	22·3	25·6
D. 118	2	30·5	39·0	43·7
D. 405	2	19·4	20·3	25·4

SERIES II.

Tons of canes per acre.

Varieties.	No. of crops.	No nitrogen.	Normal nitrogen, 60 lb. per acre.	High nitrogen, 90 lb. per acre.
B. 504	3	13·6	20·4	24·9
D. 4399	3	14·6	17·3	23·2
D. 216	3	17·9	26·4	30·8
D. 294	3	11·1	17·3	25·6
D. 281	3	13·3	22·8	21·9
D. 4395	3	16·0	20·7	22·8
D. 357	2	10·0	18·1	22·3
D. 358	2	15·8	16·5	19·2
D. 448	2	12·1	20·7	23·2
D. 355	2	7·8	14·5	21·6
D. 60	2	14·8	22·8	26·1

The following varieties have been under trial in series with one proportion (60 lb. nitrogen per acre) of sulphate of ammonia only :—

SERIES III.

Tons of canes per acre.

Varieties.	No. of crops.	No nitrogen.	Normal nitrogen, 60 lb. per acre.
D. 130	4	33·1	41·7
D. 74	4	26·9	36·2
D. 115	4	25·4	32·5
D. 95	4	28·6	31·8
D. 118	2	33·6	37·8
D. 419	2	21·3	33·5
D. 642	2	17·9	33·0
D. 167	2	17·1	29·9
D. 44	2	15·1	26·3
D. 638	2	11·6	24·4
D. 338	2	16·7	20·5
D. 65	1	13·3	27·7
D. 625	1	17·2	27·0
D. 721	1	23·0	32·3
D. 139	1	13·3	21·2
D. 4399	1	15·4	20·4
D. 333	1	14·4	20·2
D. 264	1	9·0	13·2
D. 154	1	9·6	12·4

The mean results of the various series of trials are as follows :—

	Series I.	Series II.	Series III.
No of varieties used	27	11	19
	Tons of	canes per	acre.
No nitrogen	17·8	13·4	19·1
Low nitrogen (40 lb. per acre)	23·5	...	...
Normal nitrogen (60 lb. per) ...	...	19·8	27·4
High nitrogen (80 lb. per acre)	28·1	...	...
„ „ (90 lb. per acre)	...	23·8	...

Fifty-five varieties have been used in the above trials, and every variety has been beneficially affected by manurings with nitrogen. The extents of the beneficial results appear to have been governed by the varieties of sugar-canes used, the meteorological conditions during their growths, and their suitability or adaptability to the soil conditions of the Experimental Fields.

For economic purposes the sugar-cane may be regarded as an appliance for the production of carbohydrates by the interposition of nitrogen applied to the soil. It may therefore be of interest to record the weight of canes produced by the more important varieties for each 10 lb. of nitrogen when applied in quantities not in excess of those supplied by 300 lb. of sulphate of ammonia per acre. They have been as follows :—

	Tons of canes per 10 lb. of nitrogen.
D. 419	2·00
Sealy	1·87
D. 625	1·80
D. 74	1·62
D. 145	1·62
B. 147	1·52
White Transparent	1·50
D. 118	1·42
D. 3956	1·40
D. 130	1·23
D. 95	1·18
D. 4399	1·17
Bourbon	1·15
D. 116	1·12
D. 109	0·90
B. 208	0·82
D. 4397	0·78
D. 4395	0·86

The low rate of yield of the Bourbon cane—1·15 tons of canes for each 10 lb. of nitrogen supplied as manure—compares very unfavourably with earlier results recorded in the Colony. For instance, during the New Colonial Company's experiments of 1882-7 the Bourbon cane returned 2·5 tons of canes for each 10 lb. of nitrogen added in the manures used; in the earlier trials at the Botanic Gardens from 1891-5 it yielded 1·5 tons whilst during the last few years its yield has been reduced to 0·97 ton for the same application. It is worthy of note that a similar falling-off, from 2·65 tons in 1886-90 to 1·55 tons from 1891-5, characterized the degeneration of the Bourbon cane in Barbados.

The results of our numerous trials with sulphate of ammonia as a manure to sugar-cane of many varieties indicate that when in a series of experimental field-investigations with sugar-cane of any variety, the plants do not respond to applications of sulphate of ammonia or do not appear to give increased yields from its use, the land upon which the trials are being carried out is either too irregular in its lay or in its composition, is defective in its drainage, or is otherwise unsuitable for use in field-trials. Results obtained on land of such character with manures, with various modes of treatment, or with varieties of sugar-cane are, in our opinion, unreliable.

EFFECTS ON THE SOIL OF SULPHATE OF AMMONIA AND NITRATE OF SODA.

An important question has been under investigation for some years. It has been and is frequently observed that the continuous use of sulphate of ammonia is injurious to the fertility of the soil by indirectly inducing in it a degree of acidity inimical to the growth of plants. It has been from time to time suggested that better results would be obtained on British Guiana sugar-cane soils by the substitution of a nitrate for sulphate of ammonia.

Opportunities have arisen for inquiry into this question.

Advantage was taken in 1905 of the mode in which the experiments have been conducted, to arrange trial plots for examining as to whether the continuous use of sulphate of ammonia from 1892 to 1905 had been injurious to the soil of the experimental field, and whether better results would be obtained by the substitution of nitrate of soda for sulphate of ammonia.

The previous manuring of the field allowed comparisons to be made with three varieties of canes on not-limed and on limed land:—

Sulphate of ammonia after sulphate of ammonia (fourteen years)
Sulphate of ammonia after nitrate of soda „ „
Nitrate of soda after sulphate of ammonia „ „
Nitrate of soda after nitrate of soda „ „

The following are the mean results in tons of canes per acre during the years the trials have been carried on:—

	1905.	1906.	1907.	1908.	1910.	1911.	Means.
							1905-1911.
No nitrogen ...	16·4	11·5	5·2	12·1	16·2	8·8	11·7±·5
Nitrate of soda :—							1906-1911.
After sulphate of ammonia ...	not tried	20·7	8·8	21·2	16·3	15·3	16·5±·6
After nitrate of soda	„	18·9	9·2	19·0	17·0	16·2	16·1±·6
Sulphate of ammonia :—							1905-1911.
After sulphate of ammonia ...	25·3	23·5	19·4	25·5	21·6	15·6	21·8±·8
After nitrate of soda	23·8	19·2	15·1	21·0	20·3	17·2	19·5±·7

The soil-errors incidental to the field-trials being allowed for, it is apparent that no deductions can be drawn as to injurious or non-injurious effects on the soils where nitrate of soda has been used as a nitrogenous manure after the continuous application of sulphate of ammonia or of nitrate of soda.

The results of the three earlier years apparently indicated some unfavourable action on the part of the previous applications of nitrate of soda. By reducing the increases obtained to a common basis of reference—the yields each year of the unmanured plots taken as 100—and calculating the probable errors in the means of the increases and combining these with the probable errors due to soil variations, we get the following comparisons :—

No manure	100	
Nitrate of soda after sulphate of ammonia	175	± 9·0
Nitrate of soda after nitrate of soda	166 ·	± 11·0

No weight attaches to the differences recorded during the trials.

The indications of the manurings with sulphate of ammonia can be similarly tested. The following are calculated to the yields of the unmanured plots of each year taken as 100 :—

	1905.	1906.	1907.	1908.	1910.	1911.	Mean.
After sulphate of ammonia	154·3	204·3	373·1	210·7	133·3	177·2	208·8 ± 20·8
After nitrate of soda	145·1	167·0	290·4	173·5	125·3	195·4	182·8 ± 15·0

These figures work out as increases per cent. of the yields on the plots long-manured with nitrate of soda as follows:—

1905.	1906.	1907.	1908.	1910.	1911.	Mean.
6·4	22·3	28·5	21·4	6·4	9·3	12·6 ± 4·7

and this indicates that over the whole period the earlier manurings with nitrate of soda had somewhat adversely affected the fertility of the land.

The course of the trials was interfered with by a very deep forking given to the plots in 1908-9, which appears to have greatly reduced, or nearly done away with, the differences that might have been due to the effects of the nitrate of soda on the soil. The mean increase per cent. shown by the four crops prior to the forking during which the yields on the plots long-manured with sulphate of ammonia were uniformly higher than were those on the plots which had been similarly treated with nitrate of soda is 21·1 ± 3·0, and this shows with certainty that the long-continued manurings with nitrate of soda had been injurious to the soil; whilst taking into consideration the fact that this injurious effect appears to have ceased during the crops of 1910 and 1911 it indicates that the effect was due to changes in the layers of soil immediately beneath the level to which the usual cultural operations extend. The wide range shown by the excess yields over those of the unmanured plots during the period of the trials indicates that some of the unfavourable results may have been due to meteorological conditions. It appears probable that, as may have been the case with the recent manurings with nitrate of soda, in comparisons of this sort where it is not feasible to use a large number of similarly treated plots and where the trials can, from their nature, only be carried over a few years during which the induced differences in the conditions it is desired to enquire into tend each year to lessen, meteorological conditions are the dominating factor.

NEW FORMS OF NITROGENOUS MANURES.

In addition to the comparisons of sulphate of ammonia and nitrate of soda, which have been carried on for many years past, during 1910 and 1911 comparative trials have been made with other sources of nitrogen—nitrate of lime, nitrolim (calcium cyanamide) and dried blood.

Twenty-one varieties of sugar-cane have been used for the purposes of the trials, which with each variety have been either duplicated or triplicated. The mean results of the two years' trials are shown in the following comparisons:—

Tons of canes per acre.

	Series A.	Series B.	Series C.
No Nitrogen	18·0 ± 0·4	17·7 ± 0·5	17·4 ± 0·6
Sulphate of ammonia ...	29·0 ± 0·7	30·3 ± 1·3	28·3 ± 1·3
Nitrate of lime	23·6 ± 0·6	22·5 ± 1·4	22·6 ± 1·4
Nitrolim	22·6 ± 0·6	20·9 ± 1·3	20·8 ± 1·3
Dried blood	...	20·4 ± 1·3	..
Nitrate of soda	...	...	20·8 ± 1·3

The two years have been marked by meteorological conditions which were unfavourable for the action of nitrates, large proportions of them in all probability having been lost in the drainage-waters from the plots during the heavy weather which followed soon after their application. This is shown in the following table which gives the rainfalls during the six months immediately succeeding the application of the manures, on October 1 and December 2, 1909, in which year the manures were put on in two applications, and in February 1911 when they were applied at one time :—

Months.	Inches of rain.	Months.	Inches of rain.
October 1909	6·46	February, 1911	6·32
November „	3·25	March „	13·50
December „	12·98	April „	9·16
January 1910	7·94	May „	9·96
February „	6·95	June „	10·29
March „	9·31	July „	9·55
	46·89		58·78

The state of constant saturation the land was in for some months after the application of the manures acted detrimentally to the dressings of nitrolim and of dried blood.* It is there-

* The dependence of the relative yields produced by the various forms of nitrogenous manures upon the meteorological conditions prevailing during the period of active growth of the sugar-cane is well illustrated by the results of the trials in the autumn crop of 1912. The canes experienced a persistent and exceptionally severe drought from the commencement of their growth in December 1911, to near the end of May 1912. Thence to the middle of August the weather was favourable for their growth, rains being fairly continuous although in no case were they excessively heavy. During September, October and November, the canes were again subject to an intense drought. On the original manurial experiment-field the results with manuring, supplying 60 lbs. of nitrogen per acre, were :—

Nitrate of soda	33·6	tons of cane per acre.
Sulphate of ammonia ...	25·8	„ „ „

The mean results over the whole of the trials were :—

Nitrate of lime	19·4	tons
Nitrate of soda	19·0	„
Sulphate of ammonia ...	18·6	„
Dried blood	18·4	„
Nitrolim	15·9	„

fore not advisable to draw any general deductions relative to the comparative value of the manures. It may however be of service to place on record the value in terms of tons of sugar-cane of 10 lb. of manurial nitrogen in the various substances used :—

	Tons of canes.
Sulphate of ammonia	1·91 ± ·23
Nitrate of soda	·57 ± ·29
Nitrate of lime	·87 ± ·25
Nitrolim	·62 ± ·21
Dried blood	·45 ± ·29

In a moist, hot climate like that of British Guiana it is necessary to apply nitrolim as soon as possible after its receipt as it loses its nitrogen in the form of ammonia with considerable rapidity. Nitrolim kept in British Guiana in bags for nine months in this way has lost over 60 per cent. of its nitrogen.

DANGERS OF NITRATES.

The unfavourable results obtained in several years of the trials, but more especially in 1909, 1910 and 1911, with nitrates, both where applied in single dressings and in repeated applications, should give pause to planters contemplating the substitutions of nitrates for sulphate of ammonia in the manuring of their cane fields. Over a quarter of a century's experience in comparative trials with nitrate of soda and with sulphate of ammonia has shown to us that in normal years manurings of about 2 cwt. of sulphate of ammonia and of 2½ cwt. of nitrate of soda give very similar increases; that where heavier applications are made the action of nitrate of soda is uncertain and is usually less favourable than that of sulphate of ammonia; and that in years of excessive or of heavy rainfall the beneficial effects of nitrate of soda, even in light applications, fall far below those of sulphate of ammonia.

Another important point to be borne in mind when considering the advisability of the substitution of nitrate of soda for sulphate of ammonia is the very unfavourable effect the former may have on the tilth of heavy clay soils. Repeated heavy dressings of nitrate of soda may so injure the conditions of clay soils for sugar-cane cultivation that some years will elapse before they return to their normal conditions of productivity for that crop. This may not, and probably will not, result from repeated applications of nitrate of lime, but reliable data are not yet available.

EFFECTS OF PHOSPHATIC AND POTASSIC MANURES.

The trials of phosphatic manures have been continued. It was clearly proved, prior to 1900, that on the clay-lands of British Guiana the application of phosphates was attended only by slight increases. In pages 7 and 8 of the report submitted to the Barbados Conference of 1908 the results to that dato are given. With the results of the crop of 1908 they can be summarized as follows :—

Tons of canes per acre.

		No phosphate.	Slag-phosphate.	Basic superphosphate.
Series 1.	Seven crops 1902-8	32·0 ± ·3	32·7 ± ·3	
Series 2.	Six crops 1903-8	22·4 ± 7	22·5 ± ·7	22·9 ± ·7
Series 3.	Six crops 1903-8	18·4 ± ·2	18·9 ± ·2	
Means		24·3 ± ·2	24·7 ± ·2	

These trials were conducted over such a large number of plots as to reduce the probable errors of the means of their results due to soil-conditions to approximately ± 1 per cent. When this probable error is taken into consideration the results indicate that the phosphates used were practically inert. They had not influenced the sugar-canes either beneficially or detrimentally.

The investigations entered into in 1907 having indicated to us the marked tendency that exists in the soils of British Guiana to become alkaline during cultivation, it was determined to revert to the system in force prior to 1902 of using superphosphate of lime as the phosphatic manure. One hundred and sixteen plots without, and the same number with, superphosphate have been employed in the enquiry, each year since.

The results of the trials have been as follows:—

Tons of canes per acre.

Crop.	No phosphate.	Superphosphate.
1909	21·4	22·4
1910	25·9	27·1
1911	13·4	13·7
Means	20·2±·2	21·1±·2

Comparisons between superphosphate and slag-phosphate have been resumed with the following results:—

Tons of canes per acre.

Crop.	No phosphate.	Superphosphate.	Slag-phosphate.
1909	18·6	20·4	24·0
1910	27·1	28·3	30·6
1911	15·8	15·7	17·8
Means	20,5 ±·5	21·5 ± ·5	24·1 ± ·7

It is noticeable that a slight increase, beyond the limits of the probable error, ensued on the application of superphosphate in the trials where eighty plots each with and without superphosphate were used. In the second series where only fifteen plots could be used with each form of manure the mean increased yield on the plots which received superphosphate over those which did not receive it is 1 ton per acre, practically just the limit of the probable error of the trials. But the higher mean yield of the plots which received slag-phosphate over those which received superphosphate is beyond the limit of the probable error, being 2·6 tons per acre, the probable error incidental to it working out at 1·2 tons.

The results of twenty years' trials with phosphatic manures show that the gains in tons of canes per acre by the application of phosphates fall but little outside of the limits of the probable errors due to the varying soil-conditions of the plots used.

If the results of the various years are plotted so as to show for each crop the frequencies of the increases and non-increases which ensued in the trials from the application of phosphates there appears to be clear proof that the action of the various forms of phosphates is other than ground mineral phosphates which have proved, except when applied in dressings to about $\frac{1}{2}$-ton per acre when their average increase was 6·8 $\pm$ 0·3 per cent. to be practically inert, has been beneficial and resulted in increases in the yields of canes per acre. In the trials from 1891 to 1902 the average increase due to the use of phosphates amounted to 5·3 per cent., whilst during 1902-12 it was 2·9 per cent. The very great number of comparisons made, about 1,200, reduced the error due to soil-conditions to approximately 0·3 per cent. so that during the twenty years the beneficial action of phosphatic manures on the heavy clay soils may be fairly stated as being 4·5 $\pm$ 0·3 per cent. of the yields on land not so treated. It is worthy of note that the increases due to the use of superphosphate were markedly higher from its first application than they have been from later ones, the first year's trials showing a percentage increase of 8·3 $\pm$ 2·1 per cent. The increase has since fallen to a percentage of 2·2 $\pm$ 1·5 per cent. or say from a minimum of 6·2 per cent. to one of 0·7 per cent.

It is very evident that these low increased yields cannot be financially remunerative. One of us pointed out as long ago as 1886* the minor importance of phosphates in sugar-cane manure as indicated by experiments made in Essequibo, British Guiana, in Barbados, and in Burma. The long-continued series of trials now reported fully confirms the view then expressed.

The first ten years of the trials in British Guiana indicated that when a British Guiana sugar-cane soil shows on analysis a content of 0·008 per cent. of phosphoric anhydride soluble in

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* 'Certain Points in Agricultural Chemistry, considered in Reference to the Selection and Application of Manures for the Sugar-cane,' Barbados, 1886, pp. 8 and 14.

1 per cent. nitric acid solution or of 0·002 per cent soluble in two-hundreth normal hydrochloric acid under conditions of constant shaking for five hours, manurings of phosphates in all probability will not produce correspondingly increased yields of sugar-canes, and experience during the second period of ten years has very fully confirmed the accuracy of this deduction.

POTASSIC MANURES.

No enquiries have been made at the Experimental Fields during recent years into the action of potash as a manure. It was found in 1902 that tillage had set free from the heavy clay soil of these fields readily available potash in quantities in excess of that required by the sugar-cane and it was conclusively proved during the trials from 1891 to 1902 that applications of potash salts had not been followed by increased yields of sugar-cane. It is, however, applied in small quantities to some of the plots where it is desirous to study the action of complete manures.

By the kindness of the Hon. B. Howell Jones large-scale trials of sulphate of potash have been made at Plantation Houston. The mean results of a considerable number of comparative field-trials showed that the mean yield of sugar-cane was exactly the same on land not manured with sulphate of potash as it was on land fairly heavily manured with that substance.

For reasons which will appear later in this report it is probable that certain of the plots are now approaching the stage of potash-exhaustion, and it is possible that in the course of the next two or three years it will be found necessary to apply salts of potash in quantity to these plots in order to prevent further falling-off in their fertility.

EFFECTS OF APPLICATION OF MOLASSES TO THE SOIL.

Through the kindness of the Honourable R. G. Duncan we were able to make a series of comparative experiments on the alleged beneficial action of applications of vacuum-pan molasses to soil on which sugar-cane is being cultivated. Forty-nine duplicate plots, not cross-dressed, and cross-dressed with molasses, were used for the investigation. Twenty-one of these received molasses at the rate of 100 gallons per acre, fourteen at the rate of 200 gallons per acre, and fourteen at that of 300 gallons, whilst forty-nine did not receive any molasses. Molasses given to us by Mr. Duncan was used. It had the following composition :—

Water	23·5
Saccharose	29·8
Glucose	32·0
Mineral matters*	5·9
Undetermined organic matters†	8·8
	100·0

*Containing phosphoric anhydride	·21
*Containing potash	·21
†Containing nitrogen	·18

The specific gravity of the molasses was 1·40 at 30° C. The molasses supplied the following quantities of sugars, phosphoric anhydride, potash and nitrogen to the soil per acre :—

Molasses applied.		Sugars.	Phosphoric anhydride.	Potash.	Nitrogen.
Gallons.	lb.	lb.	lb.	lb.	lb.
100	1,400	860	2·9	2·8	2·6
200	2,800	1,730	5·8	6·7	5·1
300	4,200	2,590	8·7	8·6	7·6

The mean results of the forty-nine plots not cross-dressed, and cross-dressed with molasses, were as follows :—

	Tons of canes per acre.
Without molasses	14·5±·5
With molasses	14·9±·5

The above results indicate that the molasses exerted no appreciable action. Hence its application resulted in a financial loss of about $5 to $15 per acre, according to the quantity of molasses applied.

On nine plots which did not receive any application of nitrogenous manures the returns were somewhat lower where molasses was applied than where it was not applied, being 8 tons and 8·9 tons of canes respectively. From plots which were manured with sulphate of ammonia, the following results were recorded :—

	Tons of canes per acre.
Without molasses	16·3±·6
With molasses	17·1±·6

The apparent increases were within the limits of the probable error of the trials.

On the plots manured with nitrate of soda the mean returns without and with molasses were identical—15·2 tons of canes per acre in each case.

Hence, in the year 1911, the general results of the trials gave no support to the theory that the application of molasses to the soil is beneficial to its yield of sugar-cane.* But

* The trials with molasses were continued during 1912. As for the crop of 1911 it was applied mixed with water to the plots which had received it in that year. The non-treated control plots received at the time exactly the same amounts of water as were supplied to the treated plots.

The mean results in tons of canes per acre were 27·4 without molasses and 28·0 with molasses. As in the previous years where molasses was applied to land long-cultivated without manure the returns were lowered by the applications to the extent of 26 per cent. of the yields of the corresponding non-treated plots. On the plots manured with nitrogenous manures a slight increase, equal to 3·8 per cent., was reported on the treated plots. These trials were made in both plant and ratoon canes.

The results of the two years' trials, the mean yields of the untreated plots being taken as 100, were as follows :—

	With molasses.
1911	102·7±3·3
1912	102·3±2·1
Mean results 1911 and 1912	102·5±1·6

The action of the molasses during the trials has thus been negligible.

whilst on the five series of plots consisting of thirty-five without molasses and thirty-five plots on which molasses was applied at the rate of 100 and 200 gallons per acre, the mean returns of the plots cross-dressed with molasses were lower than were those of the corresponding plots which did not receive molasses, on two series of fourteen plots without, and fourteen plots on which molasses was applied at the rate of 300 gallons per acre a mean increased yield of 1·6 ton of canes per acre was obtained on the latter. This increase is greater than the range of error expected on fourteen duplicate trials—0·9 ton of canes per acre in excess or deficit—but it is not so high as to indicate decisively a favourable action of the molasses. Assuming the increase to be due to the application of that substance, it is but very little higher than the increase in yield —1·0 ton of canes per acre—which should be due to the nitrogen contained in the molasses if that nitrogen was as effective as was nitrogen in the normal manurings of 60 lb. of sulphate of ammonia used on the fields. In fact the increased yield that might be claimed as due to the application of 300 gallons per acre of molasses would be obtained by a dressing of 50 lb. of sulphate of ammonia per acre. Assuming that the 1·6 tons of canes per acre would yield 400 lb. of total sugars in the juices expressed from them, it does not appear to be either financially or agriculturally a satisfactory procedure to apply, in round figures, 2,600 lb. of sugars to the soil with the result of getting back 400 lb.

About fifty examinations were made in each case of the juice of the canes grown without and with molasses. The mean results of the analyses were as follows :—

	Pounds per gallon.			
	Specific gravity.	Saccharose.	Glucose.	Quotient of purity.
Without molasses	1·0817	1·9308	·1147	86·9
With molasses ...	1·0830	1·9457	·1164	86·15

The quality of the juice was not beneficially affected by the application of molasses to the soil.

TRIALS WITH NITRO-BACTERINE OR NITRAGIN.

In March 1908, the West India Committee forwarded to us, with a request that it should be carefully tried, a small quantity of Professor Bottomley's Nitro-Bacterine specially prepared for use with sugar-cane. It was hoped that inoculation of the soil with this preparation would enable sugar-cane to directly utilize the nitrogen of the air as plant-food. Culture-solutions were most carefully prepared by Mr. A. W. Bartlett, according to the instructions received from Professor Bottomley and were tried in two series of experiments :—

(a) a triplicate series of pot-experiments,
(b) a series of eight field or plot-trials.

The culture solution was diluted and applied in these experiments in exact accordance with the directions received with the preparations.

(a) In the pot-experiments at no period of growth did the canes treated with the Nitro-Bacterine culture show any advantage from the application of the preparation. The canes used in these trials were of the very small variety, Brekeret. The canes were cut in December 1908, and the yield of those grown in the pots treated with Nitro-Bacterine as compared with that of those not so treated was as 97 to 100.

(b) The field-trials were made on eight half plots on the north half of the South Experimental Field, the varieties growing on them being D. 145 and D. 2468. The mean yields obtained were as follows :—

Description of Plots.	Produce in tons per acre. Without Nitro-Bacterine.	With Nitro-Bacterine.
Plots not manured ..	19·1	18·6
Plots manured with phosphates	21·3	22·4

The means of the above are 20·2 tons per acre on the plots not treated with Nitro-Bacterine and 20·5 tons on the treated plots.

The difference in yield between the treated and not treated plots is not greater than was to be expected on the very small areas, $\frac{1}{130}$-acre each, which, owing to the paucity of the material supplied to us, we were compelled to use. The mean results are for all practical purposes identical in both series and thus confirm the negative results of the pot-experiments.

It was noticed in the pot-experiments that the canes in the pots the soil of which had been treated with Professor Bottomley's preparation sprang as ratoons with considerably more vigour than did those in the control-pots. The stumps in the field-trials were therefore allowed to spring and the young canes reaped when three months old. The mean results were as follows :—

	Pounds of produce per acre.
Without Nitro-Bacterine	705
With Nitro-Bacterine	615

Hence no effect whatever was noticeable from the application of the preparation, and it may fairly be assumed that under the conditions of the experiments it was inert.

PART IV.

The Effects of Cultivation and of Manures on the Soil of the Manurial Experiment Fields.

At the commencement of the trials in 1891 samples of the soil to a depth of 8 inches were taken from each half of each of the control-plots and mixed together so as to form a representative sample of the soil of the field. Its character and composition was found to be as follows.

A greyish-coloured very heavy clay, capable of containing 42 per cent. of water when quite wet but only retaining from 6 to 7 per cent. when air-dried. Its detailed composition in the air-dried state is:—

Hygroscopic water	6·750
Combined water	6·962
Organic matters[1]	2·960

Soluble in acidulated water, ·5 grain HCl per litre:—

Ferric oxide	·014
Ferrous oxide	·144
Alumina	·204
Manganic oxide	·040
Calcium oxide[2]	·239
Magnesium oxide	·075
Potassium oxide[3]	·034
Sodium oxide	·043
Sodium chloride	·105
Phosphoric anhydride[4]	·003
Sulphuric anhydride	·023
Nitric anhydride	trace

Soluble in boiling hydrochloric acid, 20 per cent. HCl:—

Ferric oxide	4·872
Alumina	9·418
Manganic oxide	·372
Calcium oxide[5]	·087
Magnesium oxide	·610
Potassium oxide[7]	·562
Sodium oxide	·288
Phosphoric anhydride[8]	·108
Sulphuric anhydride	·122

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1. Consisting of:—

Coarsely divided plant-débris	1·15
Finely divided plant-débris	·44
Humus	1·37
1. Containing nitrogen	·177
1. Containing carbon	1·555
2. 'Lime' soluble in 1 per cent. solution of citric acid ...	·1039
3. 'Potash' ,, ,, ,, ,, ,, ,, ...	·0097
4 & 8. 'Phosphoric acid'	·0142
2, 5 & 6. Total 'lime'	·527
3. 7. Total potash	2·631
4 & 8. Total phosphoric acid	·111

Not soluble in water or acid :—

Silica set free by HCl	26·513
Quartz sand	13·493
Combined silica	7·656
Titanium oxide	·677
Ferric oxide	1·414
Alumina	12·245
Calcium oxide[6]	·184
Magnesium oxide	·131
Potassium oxide[7]	2·035
Sodium oxide	1·662
	100·050

The mechanical analysis of the soil gave the following results :—

Hygroscopic water	7·0
Coarse sand	7·2
Coarse plant débris	1·1
Fine sand	5·5
Fine plant débris	·5
Coarse silt	6·6
Fine silt	5·2
Clay	65·5
Humus	1·4
	100·0

On the above results the following opinion was based :— It is an exceptionally heavy soil containing more than 65 per cent. of clay and less than 14 per cent. of finely divided quartz-sand, an amount which has little effect in alleviating its marked binding properties. In common with the majority of tropical soils which have at any time been subject to cultivation it contains little organic matter, and in this the nitrogen is in a somewhat low ratio to the carbon. The proportions of sodium chloride and of sulphates present showed that the soil in 1891 was imperfectly drained. It contains a larger proportion of calcium oxide (lime) than is usual in sugar-cane soils in British Guiana, but as this is present wholly in the form of sulphate and silicate it can exercise little beneficial influence on the physical properties of the soil. Phosphoric anhydride is present in fair quantity, principally in a state of considerable insolubility. More than $2\frac{1}{2}$ per cent. of potash is present, a large proportion of which is in a state of easy availability. From its chemical composition this is a soil of high potential fertility but requiring tillage to enable it to produce continuously heavy crops of sugar-cane.

Careful estimations of the average weight of an acre of the soil to a depth of 8 inches have been made. The weight found is 2,350,000 lb. per Rhynland acre.

Ten years later, in 1902, after the reaping of the sugar-cane then on the land, samples were taken from the plots under various conditions of treatment and were examined as to the proportion of nitrogen, and of citric acid soluble

(1 per cent. citric acid solution) phosphoric anhydride, potash and lime present in each of the samples.

The composite 1891 sample and the 1902 samples were preserved, and have from time to time been used for reference purposes or for determinations of various constituents. Wherever marked variations have been found in samples taken later from the same plots the determinations have been repeated on the original samples and in every case the earlier results have been practically confirmed.

In 1912 similar samples were drawn and have been examined. Determinations of the humus in each of the samples and mechanical examinations of several of them have been made in addition to the various determinations made in the earlier series of samples.

During the first period of ten years the soil was under the system of continuous intensive cane-cultivation usual in British Guiana. During the second period the field was subdivided into two sections. Forty-two plots at the northern part of the field used for experiments with nitrogen were kept under continuous cultivation, a somewhat deep cultivation by forking and a naked fallow for the period of six months taking place between the reaping of the crop in June 1904, and the planting of the crop for December 1905, whilst a like treatment with very thorough forking succeeded by a naked fallow for ten months took place between the reaping of the crop of 1907 and the planting for the crop of December 1909.

On the southern section of the field, on forty-nine plots, trials with phosphoric acid manuring were continued during the ten years. After the reaping of the crop of December 1905 the land was thrown out of cultivation and was seeded with native legumes such as *Phaseolus semierectus*, *Crotalaria retusa*, *Stylosanthes procumbens*, *Desmodium* spp., etc , and allowed to be taken over by a dense growth of these and other weeds. The soil was lightly forked so as to bury the weeds when they were of about twelve months' growth ; again seeded broadcast with the seeds of the legumes and the weeds allowed to grow as best they could until April 1908 when the land was thoroughly forked and the exuberant growth upon it turned in as a green dressing prior to the subsequent planting of sugar-cane.

The general results of the crops and the analytical figures obtained from the samples taken from the two sections of the field require separate consideration.

For the purpose of approximately determining the demands on the soil by the crops of sugar-cane during the period 1902-12 the mean percentages of nitrogen, phosphoric anhydride, potash and lime as determined in earlier investigations in the various parts—stalks, tops, and leaves—of the crops reaped were used. These are as follows:—

	Canes.	Plants.	Leaves.
Nitrogen	·068	·166	·380
Phosphoric anhydride	·063	·164	·181
Potash	·135	·561	·875
Lime	·136	·073	·140

The figures correspond to the following amounts of the various constituents in pounds per ton of the various parts of the crops as reaped :—

	Canes.	Plants.	Leaves.
Nitrogen	1·52	3·72	8·50
Phosphoric anhydride	1·41	3·67	4·05
Potash	3·02	12·56	19·60
Lime	·80	1·63	3·13

We are aware that where heavy or excessive dressings of nitrogen or of readily soluble phosphates or of potash are applied as manures there is a tendency for some part of the heavy dressings or excesses to be stored in the produce, but for our present purpose it is not necessary, or indeed feasible, to take this into consideration. The weights of produce taken into consideration are those determined on each of the plots from the soils of which analytical figures have been obtained.

During the second period, from certain of the various series of plots, the tops of the canes have been supplied to planters and not, as they were during the first period, returned to the soil. The effects of this may be illustrated by the case of the series occupied by D. 145 the mean yields of which were :—

	Tons per acre, 1902-12.			
	Stalks or canes.	Tops or plants.	Leaves.	Total produce reaped.
Eight crops ...	145·8	30·4	16·3	192·5
These contained, in pounds per acre :—				
Nitrogen	221·7	113·2	138·5	473·4
Phosphoric anhydride	205·6	127·3	65·6	398·5
Potash	440·3	381·8	321·0	1,143·1
Lime	116·4	49·5	51·0	217·1

In eight crops the tops removed in round figures 1 cwt. of nitrogen equivalent to about 5 cwt. of commercial sulphate of ammonia, $1\frac{1}{8}$ cwt. of phosphoric anhydride equivalent to that contained in 7 cwt. of 18 per cent. slag phosphate, $3\frac{1}{2}$ cwt. of potash equivalent to that contained in 7 cwt. of commercial sulphate of potash, and a little less than 50 lb. of lime. The greatly increased demand on the constituents of the soil and manures caused by the tops or plants not being returned to the soil has to be taken into careful consideration and is allowed for in subsequent calculations. This demand requires special attention in cases where land is set apart as nurseries for the supply of cane plants to sugar-plantations.

TRIALS WITH NITROGEN ON SOIL UNDER CONTINUOUS CULTIVATION WITH TWO PERIODS OF BARE FALLOW.

UNMANURED PLOTS. The soil in 1891 contained ·177 per cent. of nitrogen, in 1902 it yielded ·156 per cent. and in 1912 ·087 per cent. On the half plots which received lime in 1891 the soil contained ·126 per cent. of nitrogen in 1902 and ·079 in 1912. These correspond to 4,160 lb., 3,670 lb. and 2,040 lb. per acre in the not-limed land and to 4,160 lb., 2,960 lb. and 1,860 lb. in the limed land. The results are summarized as follows :—

Nitrogen, pounds per acre.

Treatment.	In soil, 1902.	Added in rain.	In soil, 1912.	Removed in crops, 1902-12.	Loss 1902-1912.
Not limed	3,670	29	2,040	134	1,325
Limed	2,960	29	1,860	133	996

During the whole period of the trials the results have been as follows :—

Nitrogen, pounds per acre.

Treatment.	In soil, 1891.	Added in rain.	In soil, 1912.	Removed in crops, 1891-1912.	Loss 1891-1912.
Not limed	4,160	57	2,040	344	1,833
Limed	4,160	57	1,860	363	1,994

MANURED WITH PHOSPHATES AND POTASH. The soil of the not-limed plots of this group in 1902 contained ·133 per cent. of nitrogen ; in 1912 it yielded ·098 per cent. That of the limed plots in 1902 was determined to be ·133 per cent., whilst in 1912 it was ·098 per cent. The records for these plots for the second period of ten years are :—

Nitrogen, pounds per acre

Treatment.	In soil, 1902.	Added in rain.	In soil, 1912.	Removed in crops, 1902-12.	Loss, 1902-12.
Not limed	3,130	29	2,300	134	725
Limed	3,130	29	2,300	149	710

and for the two periods :—

Treatment.	In soil, 1891.	Added in rain.	In soil 1912.	Removed in crops, 1891-1912.	Loss 1891-1912.
Not limed	4,160	57	2,300	343	1,574
Limed	4,160	57	2,300	387	1,530

The unaccounted-for losses of nitrogen from the soil in those plots which have been cultivated without nitrogenous manures for twenty-one years are 1,730 lb., of which from the unmanured land 1,160 lb. were lost during the second period whilst from the land manured with phosphates and potash 718 lb. were lost.

MANURED WITH SULPHATE OF AMMONIA ONLY. The soil of these plots where not-limed yielded ·146 per cent. of nitrogen in 1902 and ·105 in 1912. Where limed it contained ·156 per cent. and ·098 per cent., respectively. Its records are :—

Nitrogen, pounds per acre.

Treatment.	In soil, 1902.	Added in rain and manure	In soil, 1912.	Removed in crops, 1902-12.	Loss, 1902-12.
Not limed	3,430	309	2,470	200	1,069
Limed	3,670	309	2,300	213	1,466

and for the twenty-one years :—

Treatment.	In soil, 1891.	Added in rain and manure.	In soil, 1912.	Removed in crops, 1891-1912.	Loss 1891-1912.
Not limed	4,160	657	2,470	464	1,883
Limed	4,160	657	2,300	523	1,994

POTASH, PHOSPHATES AND SULPHATE OF AMMONIA. The soil of these plots, where not-limed contained ·136 per cent. of nitrogen in 1902 which was reduced to ·108 in 1912. The limed soil contained ·156 per cent. in 1902 and ·098 per cent. in 1912. Its records are.

Treatment.	In soil, 1902.	Added in rain and manure.	In soil, 1912.	Removed in crops, 1902-12.	Loss, 1902-12.
Not limed	3,200	396	2,540	208	848
Limed	3,670	396	2,300	252	1,518

and for the whole period :—

Treatment.	In soil, 1891.	Added in rain and manure.	In soil, 1912.	Removed in crops, 1891-1912.	Loss, 1891-1912.
Not limed	4,160	904	2,540	488	2,036
Limed	4,160	904	2,300	586	2,178

NITRATE OF SODA ONLY. When nitrate of soda was applied, the soil, where not-limed, contained ·156 per cent. of nitrogen in 1902 and ·133 per cent in 1912. The limed part yielded ·140 in 1902 and ·119 in 1912. Its records are :—

Nitrogen, pounds per acre.

Treatment.	In soil, 1902.	Added in rain and manure.	In soil, 1912.	Removed in crops, 1902-12.	Loss, 1902-12.
Not limed	3,670	396	3,125	251	690
Limed	3,290	396	2,796	278	712

and for the whole of the crops :—

Treatment.	In soil, 1891.	Added in rain and manure.	In soil, 1912.	Removed in crops, 1891-1912.	Loss, 1891-1912.
Not limed	4,160	904	3,125	510	1,429
Limed	4,160	904	2,796	610	1,658

PHOSPHATES, POTASH AND NITRATE OF SODA. The soil of the unlimed plots of this series yielded ·129 per cent. of nitrogen in 1902 and ·112 per cent. in 1912. The limed soil contained ·132 per cent. of nitrogen in 1902 and ·112 per cent. in 1912. Its records are :—

Nitrogen, pounds per acre.

Treatment.	In soil, 1891.	Added in rain and manure.	In soil, 1912.	Removed in crops, 1902-12.	Loss, 1902-12.
Not limed	3,030	349	2,600	205	574
Limed	3,100	349	2,600	218	651

and for the twenty-one years :—

Treatment.	In soil, 1891.	Added in rain and manure.	In soil, 1912.	Removed in crops, 1891-1912.	Loss, 1891-1912.
Not limed	4,160	917	2,600	468	2,009
Limed	4,160	917	2,600	540	1,937

Certain plots which were manured during the earlier crops of the experiments with sulphate of ammonia or with nitrate of soda, during the last six crops were manured respectively with nitrate of soda or with sulphate of ammonia. The not-limed soil of these plots contained ·133 per cent of nitrogen in 1902 and ·105 per cent. in 1912. On the limed soil the respective figures were ·144 and ·107 per cent.

The records of these trials during the first period were :—

Nitrogen, pounds per acre.

Treatment.	In soil, 1902.	Added in rain and manure.	In soil, 1912.	Removed in crops, 1902-12.	Loss, 1902-12.
Not limed	3,130	349	2,470	237	772
Limed	3,180	349	2,494	228	807

For the whole period of the trials the records are :—

Treatment.	In soil, 1891.	Added in rain and manure.	In soil, 1912.	Removed in crops, 1891-1912.	Loss, 1891-1912.
Not limed	4,160	857	2,470	509	2,038
Limed	4,160	857	2,494	556	1,967

STABLE MANURE. A group of plots has been manured with stable-manure applied to the plant canes of each series of cane crops with the exception of that which commenced in 1908-9. The plots during the years 1891 to 1905 received stable-manure amounting to 35 tons per acre. As ratoons during this period, the canes on these plots were manured with 200 lb. of sulphate of ammonia for each crop. Since then they have not been so manured. The soil of these plots when examined in 1902, as a mean of four closely concordant determinations contained ·213 per cent. of nitrogen, thus indicating an increase during the ten years of ·036 per cent. The 1902 sample was re-examined in 1912 with results which fully confirmed those of the earlier tests. The soil of the not-limed plots of this group in 1912 yielded ·124 per cent. of nitrogen, whilst that of the limed plots contained ·112 per cent.

The records of these plots for the period 1902-12 are :—

Nitrogen, pounds per acre.

Treatment.	In soil, 1902.	Added in rain and manure.	In soil, 1912.	Removed in crops, 1902-12.	Loss, 1902-12.
Not limed	5,010	365	2,910	152	2,303
Limed	5,010	365	2,630	173	2,572

From 1891 to 1912 the records show :—

Treatment.	In soil, 1891.	Added in rain and manure.	In soil, 1912.	Removed in crops 1891-1912.	Loss, 1891-1912.
Not limed	4,160	1,581	2,910	434	2,397
Limed	4,160	1,581	2,630	453	2,654

STABLE-MANURE WITH CINEREALS* OR NITROGEN. Another group was manured similarly to the last-mentioned with stable-manure to plant-canes and with nitrate of soda in place of sulphate of ammonia to the ratoon canes until 1905. Since then the canes have been treated with sulphate of ammonia (200 lb. per acre) or with superphosphate of lime in alternate years, the object being by these additions to bring into action the stores of inert plant-food contributed by the earlier applications of stable-manure. The applications of sulphate of ammonia were successful in their results, those of superphosphate of lime were failures. The soils of the not-limed and of the limed plots in 1902 yielded ·213 per cent. of nitrogen ; in 1912 their respective contents were ·124 and ·112 per cent. During the period 1902-12 the results have been as follows :—

Nitrogen, pounds per acre.

Treatment.	In soil, 1902.	Added in rain and manure.	In soil, 1912.	Removed in crops 1902-12.	Loss, 1902-12.
Not limed	5,010	435	2,960	182	2,313
Limed	5,010	435	2,470	183	2,802

From 1891 to 1912 the records are as follows :—

Treatment.	In soil, 1891.	Added in rain and manure.	In soil, 1912.	Removed in crops, 1891-1912.	Loss, 1891-1912.
Not limed	4,160	1,667	2,960	464	2,497
Limed	4,160	1,667	2,470	465	2,886

In both groups of plots manured with stable manure the stored-up nitrogen of the manure which in 1902 amounted to 902 lb. per acre has been lost during the period which has elapsed since the last application of stable manure in 1904.

*Cinereals : in each case either 375 lb. of superphosphate of lime or 500 lb. of slag-phosphate and 50 lb. of sulphate of potash per acre.

Of the various trials on not-limed and limed land, the results are tabulated as follows :—

Nitrogen in pounds per acre, sixteen crops 1891-1902.

Treatment.	Nitrogen added per crop.	Plots not limed in 1891.		Plots limed in 1891.	
		Removed in produce.	Loss.	Removed in produce.	Loss.
No added nitrogen	nil	343	1,702	375	1,762
Sulphate of ammonia	40 lb.	464	1,883	523	1,994
Cinereals and sulphate of ammonia	60 „	488	2,036	586	2,178
Nitrate of soda	40 „	510	1,429	610	1,658
Cinereals and nitrate of soda	60 „	468	2,009	540	1,937
Cinereals and alternations of ammonia and nitrate of soda	60 „	509	2,038	556	1,967
Stable-manure and nitrogen etc.	100 „	449	2,447	459	2,770
Means		462	1,940	521	2,035

It is evident that as the proportions of added nitrogen increase so do the losses of nitrogen per acre, and that, on the average, for every 34 lb. of nitrogen removed in the produce in each crop 125 lb. have been lost by drainage. That is, of the drain on the soil and manure for nitrogen by the system of continuous intensive cultivation, only one quarter has been incurred by the produce removed from the soil. With the exceptions of the manurings with cinereals and nitrate of soda, and with cinereals and alternations of sulphate of ammonia and nitrate of soda, the losses have been greater on the limed soils than on the non-limed ones. During the sixteen crops where no nitrogen was applied the mean loss of nitrogen was 108 lb. per crop; where sulphate of ammonia was the source of nitrogen, 126 lb.; where nitrate of soda was the source, 107 lb.; and where the nitrogen was supplied by stable-manure supplemented by sulphate of ammonia or nitrate of soda, 161 lb.

LAND FALLOWED WITH NATIVE HERBAGE AS COVER-CROPS.

On this section of the field the tops of the canes have been removed from the land in every crop from 1902 to 1912. In 1891 the mean nitrogen-content of the soil was ·177 per cent., in 1902 the soil where manured with nitrogenous manures contained ·1478 per cent., whilst in 1912 it had ·1456 per cent. The not-manured soil contained in 1902 in its not-limed and limed parts ·156 and ·126 per cent. of nitrogen; in 1912 their proportions had become ·122 and ·126 respectively. On the six crops between 1902 and 1912 the mean results of the plots not-manured and of the plots uniformly manured with sulphate of ammonia are recorded as follows:—

Nitrogen in pounds per acre.

Treatment.	In soil, 1902.	Added in rain and manure.	In soil, 1912.	Removed in crops, 1902-12.	Loss, 1902-12.
Not manured	3,315	29	2,914	138	292
Manured	3,473	358	3,423	217	191

Between 1891 and 1902 the records were:—

Treatment.	In soil, 1891.	Added in rain and manure.	In soil, 1902.	Removed in crops, 1891-1902.	Loss, 1891-1902.
Not manured	4,160	28	3,315	188	625
Manured	4,160	508	3,473	283	912

Whilst for the whole period they are:—

Treatment.	In soil, 1891.	Added in rain and manure.	In soil, 1912.	Removed in crops, 1891-1912.	Loss, 1891-1912.
Not manured	4,160	57	2,914	326	
Manured	4,160	866	3,423	500	

During the period of fallowing from cane-cultivation with native herbage as cover-crops there was a gain of nitrogen and a greatly decreased loss of that constituent by drainage. This has resulted in the loss of nitrogen in the not-manured soil of 292 lb. per acre or at the rate of 48·6 lb. per crop of sugar-cane whilst on the land manured with nitrogenous manures (sulphate of ammonia) the loss was 191 lb. or 32 lb. per crop. These compare very favourably with the losses of 1,160 and 1,180 lb. during this period recorded on similarly treated plots on the soil intensively cultivated with two intervening periods of clean weeding where the content of nitrogen has been lowered from a mean of ·147 in 1902 to one of ·103 in 1912. It also compares favourably with the losses of 625 and 912 lb.

of nitrogen per acre on the unmanured and manured plots during the period 1891 to 1902. The following comparison is instructive :—

Loss of nitrogen, pounds per acre.

Period.	Naked fallow or clean weeding.		Native herbage as cover-crops from 1902.	
	Not manured.	Manured.	Not manured.	Manured.
1891-1902	758	820	625	912
1902-1912	1,160	1,225	292	191
1891-1912	1,918	2,045	977	1,103

Preceding paragraphs dealing with the application of stable-manure in large quantity during the years 1891-1902 show that during this period the loss of nitrogen from the soil was very low, 89 lb. only from the soil of the not-limed plots and 84 lb from that of the limed ones. The effects of growing native herbage for cover-crops and turning in the vegetable matter thereby obtained as green dressings has been very similar to that then attendant on the application of 60 tons of stable-manure per acre.

The comparison very distinctly shows the beneficial effects due to the increase and conservation of the soil nitrogen by fallowing with native herbage as cover-crops.

EFFECTS OF THE CULTIVATION AND MANURINGS ON THE HUMUS OF THE SOIL.

For many years it has been held that intensive cultivation of the soil in the tropics results in a rapid impoverishment of the soil in that portion of its organic débris which is termed 'humus.' Great stress is constantly laid on the importance of its conservation, and numerous virtues are ascribed to the presence of humus in quantity. One of us in 1886 stated : 'A most important point also, and one which I can scarcely impress upon you too strongly, is the very great mechanical improvement in the condition of the soil produced by pen-manure and by vegetable green manures. The soils heavily manured with these become much more retentive of moisture which is a most valuable property in our climate, whilst the addition of the very large proportion of organic matter contained in the manures increases the amount of humus in the soil; and, as the activity of the nitrifying organisms present, (both those which oxidize ammonia into nitrates, so preparing it for plant-food, and those which possibly occasion the assimilation of the free nitrogen of the air) depends in great measure upon the amount of this substance present, which apparently acts as food for them, the importance of such increase is evident.' But as far as we are aware few if any investigations have been made into the questions of the actual agricultural value of humus and of its rate of destruction during intensive tropical cultivation. In this paper by 'humus' is meant the dark-coloured organic part of the soil that after treatment of the soil with dilute hydrochloric acid is soluble in ammonia, in sodium hydrate, or in sodium carbonate solution, and in similar alkaline media.

At the commencement of the trials the soil of the Manurial Experiment Field was found to contain 2·96 per cent. of organic matters, of which 1·16 per cent. was coarse-textured, slightly altered vegetable débris, 0·44 finely divided and much altered vegetable débris and 1·37 was humus. During the period of the experiments the coarse-textured vegetable débris has not decreased in amount but on the plots on which heavy crops have been obtained has somewhat increased. On the other hand there have been marked changes in the proportions of the humus-substances as is shown in the ensuing account. In this, as has been done in the case of the nitrogen of the soil, the two differently treated parts of the field are separately discussed.

SOIL UNDER CONTINUOUS CULTIVATION WITH TWO PERIODS OF BARE FALLOW.

NOT-MANURED AND NO NITROGEN PLOTS. The humus on the soil of the plots not limed in 1891 fell from a mean content of 1·37 per cent. to ·89 per cent. in 1902 and to ·854 per cent. in 1912. On the limed plots it decreased to ·794 per cent. in 1902 and to ·540 per cent in 1912. Similarly the soil of the plots which received potash and phosphates only decreased in its humus content in the not-limed parts to 1·055 per cent. in 1902 and to ·794 per cent. in 1912, whilst the decreases on the limed parts were to ·904 and to ·616 per cent. respectively. These figures indicate that the unlimed soil lost, where not-manured with nitrogenous manure, a mean of 9,304 lb. of humus (nearly $4\frac{1}{6}$ tons) from 1891 to 1902 and 3,525 lb. from 1902 to 1912, a total loss in the twenty-one years of 5·7 tons of humus per Rhynland acre. Similarly the limed land lost 12,240 lb. in the first period and 6,368 lb. in the second, a total loss of 8·3 tons of humus per acre.

MANURING WITH SULPHATE OF AMMONIA. Where sulphate of ammonia was applied in the manures used the loss was less. The proportions of humus found in the soils thus manured were as follows:—

Humus per cent. of soil.

	Soil not limed.			Soil limed.		
	1891.	1902.	1912.	1891.	1902.	1912.
Sulphate of ammonia only	1·37	·966	·931	1·37	1·068	·904
Cinereals and sulphate of ammonia	„	·911	·877	„	1·034	·849

The mean losses have been as follows:—

Pounds of humus per Rhynland acre.

	1891 to 1902.	1902 to 1912.	1891 to 1912.
Not limed ...	10,135	800	10,935
Limed	7,490	4,105	11,595

The total losses during twenty-one years have been in round figures 4·9 tons and 5·2 tons of humus per acre respectively on the soils of the not-limed and limed plots.

MANURING WITH NITRATE OF SODA. The plots which were dressed with nitrate of soda only and with nitrate of soda and cinereals supplied the following figures :—

Humus per cent.

	Soil not limed.			Soil limed.		
	1891.	1902.	1912.	1891.	1902.	1912.
Nitrate of soda only ..	1·37	·945	·941	1·37	·918	·835
Nitrate of soda with cinereals	„	·740	·685	„	·726	·603

The losses in the nitrate group are higher than in the ammonia one. The mean losses have been as follows : —

Pounds of humus per Rhynland acre.

	1891-1902.	1902-1912.	1891-1912.
Not limed. ..	12,390	1,116	13,506
Limed	12,875	3,870	15,300

Here the losses during the twenty-one years have been in round figures 6 tons and 6·8 tons of humus respectively on the limed and not-limed land.

STABLE-MANURE. It would be expected that the losses on the land dressed with stable-manure would be less than on others of the soils under treatment. The mean results were :—

Humus per cent,

	1891.	1902.	1912.
Not limed	1·37	·808	·808
Limed	„	·808	·780

The losses of humus therefore in pounds per Rhynland acre were :—

	1891-1902.	1902-12.	1891-12.
Not limed ...	13,200	nil	13,200
Limed	13,300	650	13,850

These are equivalent to 5·9 and to 6·2 tons of humus per acre, respectively, on the not-limed and limed land.

From the above records the following have been the losses of humus in tons per acre during the twenty-one years on not-limed and limed soils :—

	Not limed.	Limed.	Means.
No nitrogen	5·7	8·3	7·0
Sulphate of ammonia ...	4·9	5·2	5·05
Nitrate of soda	6·0	7·4	6·7
Stable-manure	5·9	6·2	6·05
Means	5·6	6·8	...

Confirmatory results were obtained on the plots which had been manured with sulphate of ammonia after long-continued treatment with nitrate of soda, or with nitrate of soda after oft-repeated dressings of sulphate of ammonia, the greater portion of the loss having taken place during the earlier periods. These results are :—

	Humus per cent. in soil,		Loss of humus in tons per acre.
	1891.	1912.	
Nitrate after ammonia ...	1·370	·835	6·2
Ammonia after nitrate ...	1·370	·766	6·3

LAND FALLOWED WITH NATIVE HERBAGE FOR COVER-CROPS.

The following are the means of the analytical determinations which were made on samples from twenty-one plots of this soil :—

	Humus per cent,		
	1891.	1902.	1912.
Not manured ...	1·370	·842	·936
Manured	1·370	·955	·968

These indicate that in the period 1891 to 1902 a loss of 12,500 lb., or about 5·6 tons of humus per acre, took place in the not-manured plots ; whilst on the manured plots a loss of 9,752 lb. or 4·3 tons of humus per acre ensued, which is higher than the 3·9 tons which for the same period characterized the plots similarly dressed with sulphate of ammonia on the northern half of the field.

From 1902 to 1912 a mean accumulation of 3,340 lb. of humus per acre took place on the unmanured plots whilst a mean gain of 305 lb. is shown on the manured plots. During the latter period the losses on the similarly treated plots on the land not planted with cover-crops were in round figures 1·5 ton and 1·1 ton on the unmanured and manured lands respectively.

It is thus evident that the system of fallowing with native herbage, largely leguminous, is one calculated to conserve the nitrogen and the humus of the soil. During the period 1902-12 the loss of nitrogen was reduced from 1,225 lb. to 191 lb. per acre, whilst a mean loss of 1·3 ton of humus per acre on the land not so treated was replaced by a gain of, in round figures, 2,740 lb. or 1·2 ton of humus per acre.

To trace the humus lost determinations of the humus present in the soil-waters from the manurial experiment-field at the southern part of the field were made. They were found to contain a mean of 260·3 milligrams of humus per litre. Waters from the northern end had a mean content of 329 milligrams of humus per litre. It is thus clear that the humus in our soil is removed to some extent through its solubility in the alkaline soil-waters.

THE RÔLE OF HUMUS IN TROPICAL AGRICULTURE.

What value has humus in the Tropics as an ameliorant of the soil and in increasing its fertility? This question is a difficult one. Consideration of the yields of certain of the groups of plots may assist in its elucidation. The groups of plots and their content of humus to be considered are the following:—

Treatment.	Humus in the soil, 1902. Not limed.		Limed.	
	Per cent. of soil.	Pounds per acre.	Per cent. of soil.	Pounds per acre.
Not manured	·890	20,950	·798	18,659
Cinereals only	1·055	24,792	·908	21,244
Sulphate of ammonia only	·966	22,701	·924	21,734
Nitrate of soda only	·945	22,207	·918	21,573
Cinereals and sulphate of ammonia	·904	21,244	1·019	23,829

The mean yields of produce per acre—canes, cane-tops, leaves, trash and fallen leaves—on the plots of these groups from 1902 to 1912 were as follows:—

	Tons per acre. Not limed.	Limed.
Not manured	113	118
Cinereals only	120	128
Sulphate of ammonia only ...	162	175
Nitrate of soda only	204	223
Cinereals and sulphate of ammonia.	195	218

On four of the series the crops were uniformly high on the land of low content of humus, whilst on the fifth the opposite was the case.

In the crop of 1910 when the differences in the humus content were practically as they are at present, the yields were determined in the parts of the field on which the humus had been reduced from 1·37 per cent. to 0·864 and to 0·743, respectively—a difference of 1·27 tons of humus per acre. The plots the soils of which contained the higher proportions of humus yielded 38,600 lb. of sugar-cane, whilst those on the soils with the lower proportions yielded 38,800 lb., thus indicating that the difference of 1·27 tons of humus per acre had been without significance.

The following table, however, indicates that as a general rule the larger the crops the greater was the destruction, or the removal, of the humus :—

	Not-limed			Limed.		
	Produce : tons per acre. 1902-12.			Humus per cent. of soil. 1902.		
Not manured ...	113	·890	·854	118	·794	·540
Cinereals only ...	120	1·055	·794	128	·904	·616
Sulphate of ammonia only ...	162	·966	·931	196	1·068	·904
Cinereals and sulphate of ammonia	195	·911	·877	218	1·034	·849
Nitrate of soda only	204	·945	·941	223	·918	·712
Cinereals and nitrate of soda ...		·740	·885	190	·776	·603
Stable-manure ...	134	·808	·808	146	·808	·780
Means	174	·900	·715	160	·901	·842

It appears from the above table that where the increases in the crops were due to causes other than the application of nitrogenous manures, these increases were accompanied by a considerable destruction, or removal, of humus. This, however, was not the case where the increases were due to the employment of nitrogenous manures.

It is a matter of much interest that the system followed in British Guiana of manuring with sulphate of ammonia, with or without potash and phosphates as the needs of the plantation suggest, with intervening resting or fallowing from cane-cultivation during which the land becomes covered with native herbage, largely leguminous, is one accompanied by conservation and by possibly increment of the nitrogen and the humus constituents of the soil.

THE CITRIC ACID SOLUBLE OR 'AVAILABLE PHOSPHORIC ANHYDRIDE OF THE SOIL.

The following table shows the determinations of 'available phosphoric anhydride in the soils of the plots that have been under naked-fallow treatment :—

Per cent. of air-dried soil.

	Original soil, 1891.	Soil not limed,		Soil limed,	
		1902.	1912.	1902.	1912.
Not manured	·0142	·0103	·0100	·0103	·0098
Cinereals only	„	·0115	·0131	·0139	·0105
Sulphate of ammonia ...	„	·0120	·0127	·0115	·0112
Nitrate of soda	„	·0102	·0140	·0105	·0110
Cinereals and sulphate of ammonia	„	·0092	·0262	·0138	·0334
Cinereals and nitrate of soda	„	·0103	·0218	·0092	·0180
Cinereals and alternations of ammonia and nitrate of soda	„	·0098	·0159	·0115	·0153
Stable-manure	„	·0080	·0229	·0080	·0327
Stable-manure and cinereals	„	.0080	·0249	·0080	·0264

In the following tables, the records from 1902 to 1912 of available' phosphoric anhydride in pounds per acre are given :—

Soil not limed.

	In soil, 1902.	Added in manure.	In soil, 1912.	Removed in produce.	Rendered available from soil.	Rendered insoluble in soil.
Not manured	240	nil	235	124	117	...
Cinerals only	270	378	308	126	...	214
Sulphate of ammonia ..	282	nil	298	187	203	...
Nitrate of soda	240	„	329	235	324	...
Cinereals and sulphate of ammonia	216	378	616	208	220	..
Cinereals and nitrate of soda	242	„	512	161	53	...
Cinereals and alternations of ammonia and nitrate of soda ...	230	„	373	218	...	...
Stable-manure	188	269	567	159	264	19
Stable-manure and cinereals	188	512	584	143	27	...

Limed soil.

	In soil, 1902.	Added in manure.	In soil, 1912.	Removed in produce.	Rendered available from soil.	Rendered insoluble in soil.
Not manured	242	nil	230	125	113	...
Cinereals only	327	378	247	140	...	318
Sulphate of ammonia ..	270	nil	263	200	193	...
Nitrate of soda	247	„	258	292	303	...
Cinereals and sulphate of ammonia	324	378	785	243	326	...
Cinereals and nitrate of soda	216	„	423	164	...	87
Cinereals and alternations of ammonia and nitrate of soda ...	270	„	359	216	...	73
Stable-manure	188	269	768	170	473	..
Stable-manure and cinereals	188	512	620	150	50	...

For the full period the records are :—

Soil not limed.

	In soil, 1891.	Added in manure.	In soil, 1912.	Removed in produce.	Rendered available from soil.	Rendered insoluble in soil.
Not manured	383	nil	235	300	152	...
Cinereals only	„	778	308	302	...	551
Sulphate of ammonia ...	„	nil	298	451	366	...
Nitrate of soda	„	„	329	486	432	...
Cinereals and sulphate of ammonia	„	778	616	482	...	63
Cinereals and nitrate of soda	„	778	512	425	...	231
Cinereals and alternations of ammonia and nitrate of soda ...	„	778	373	476	...	312
Stable-manure	„	941	567	413	...	344
Stable-manure and cinereals	„	1,184	584	398	...	585

Limed soil.

	In soil, 1891.	Added in manure.	In soil, 1912.	Removed in produce.	Rendered available from soil.	Rendered insoluble in soil.
Not manured	383	nil	230	325	172	...
Cinereals only	„	778	247	305	...	509
Sulphate of ammonia ...	„	nil	263	506	386	...
Nitrate of soda	„	nil	258	623	498	...
Cinereals and sulphate of ammonia	„	778	785	571	95	...
Cinereals and nitrate of soda	„	778	423	480	...	258
Cinereals and alternations of ammonia and nitrate of soda ...	„	778	359	538	...	264
Stable-manure	„	941	768	477	...	79
Stable-manure and cinereals	„	1,184	620	472	...	475

At the expiration of the first period, 1891 to 1902, of the trials, the following opinion was expressed :—

'The average results with and without superphosphate show that crops removing 234 lb. of phosphoric anhydride from the soils have lessened the proportion of phosphoric anhydride soluble in 1 per cent. citric acid solution by 133 lb. per acre in the first 8 inches of soil, while the addition of 400 lb. of phosphoric anhydride per acre in a soluble state in the manures applied has only resulted in decreasing the loss from 133 lb. to 32 lb. in place of increasing the proportion present by one hundred and forty-four pounds—the difference between the amount of phosphoric anhydride added and that (256 lb.) removed in the crops.'

In the second period, during which greatly improved drainage has been in operation and the tillage has been better, instead of the phosphoric anhydride added in the manures being rendered inert as indicated by analysis, with the exception of on a few plots, the stores of citric acid insoluble phosphates in the soil have been drawn upon so that, as a general rule, the proportions of phosphoric anhydride soluble in 1 per cent. citric acid solution are practically the same or are higher in the samples of soil taken from the plots in 1912 than they were in those taken in 1902. The latter is markedly the case in certain of the groups of plots where nitrogenous manures were applied.

When the whole period is considered, the indications are that, on plots which have not received any phosphates as manure, a considerable proportion of the apparently chemically inert phosphates of the soil have been drawn upon to supply the demands of the crops. In the great majority of the other cases varying quantities of the phosphoric anhydride applied in the manures have been rendered inert in the soil as indicated by analytical tests.

SECTION FALLOWED WITH NATIVE HERBAGE AS COVER-CROPS.

On this section of the field three variations in the treatments call for comment. These are plots which have not received any manure, others which have not had any phosphatic manurings, and plots which have been dressed with manures containing either superphosphate of lime or slag-phosphate continuously during the trials. The analytical results are as follows :—

Phosphoric anhydride, per cent. and pounds per acre in soil, 1891-1912.

	1891.		1902.		1912.	
	Per cent.	Pounds per acre.	Per cent.	Pounds per acre.	Per cent.	Pounds per acre.
No manure	·0142	334	·0086	202	·0105	247
No phosphates... ...	·0142	334	·0155	364	·0161	378
Phosphates	0142	334	·0135	317	·0236	555

The records of the plots in pounds of phosphoric anhydride per acre are as follows:—

1902-1912.

	In soil, 1902.	Added in manure.	Removed in produce.	In soil, 1912.	Rendered available from soil.	Rendered insoluble in soil.
No manure	202	nil	254	247	299	...
No phosphates... ...	364	nil	264	378	278	...
Phosphates	317	255	196	555	189	...

1891-1912.

	In soil, 1891.	Added in manure.	Removed in produce.	In soil, 1912.	Rendered available from soil.	Rendered insoluble in soil.
No manure	334	nil	449	247	362	...
No phosphates... ...	334	nil	474	378	418	...
Phosphates	334	740	468	555	...	51

During the second period there has been a drain on the soil's stores of apparently inert phosphates, both on the plots which received phosphates and those which did not. During the whole period there has been a demand on the apparently inert phosphates of the soil on the plots which did not receive phosphates, whilst where phosphates were supplied there was

added an excess of phosphoric anhydride, which in part remains in the soil as phosphoric anhydride soluble in 1 per cent. citric acid, and in part is inert to that solvent.

The Citric Acid Soluble or 'Available' Potash in the Soil.

[naked-fallow section.]

The following table shows the determinations of 'available' potash soluble in 1 per cent. citric acid solution in the soils of the plots which were under naked-fallow treatment :—

Per cent. of air-dried soil.

	Original soil,	Soil not limed,		Soil limed,	
	1891.	1902.	1912.	1902.	1912.
Not manured	·0097	·0140	·0048	·0160	·0077
Cinereals only	„	·0213	·0077	·0267	·0087
Sulphate of ammonia	„	·0117	·0068	·0142	·0058
Nitrate of soda	„	·0131	·0050	·0139	·0050
Cinereals and sulphate of ammonia	„	·0084	·0077	·0117	·0087
Cinereals and nitrate of soda ...	„	·0077	·0058	·0109	·0058
Cinereals and alternations of sulphate of ammonia and nitrate of soda	„	·0081	·0071	·0113	·0065
Stable-manure	„	·0135	·0116	·0135	·0077
Stable-manure and cinereals ...	„	·0135	·0087	·0130	·0097

In the following table are given the records from 1902 to 1912 of available potash in pounds per acre :—

Soil not limed.

	In soil, 1902.	Added in manure.	In soil, 1912.	Removed in produce.	Rendered available from soil.	Rendered insoluble in soil.
Not manured	329	nil	113	297	81	...
Cinereals only ..	500	175	181	295	...	199
Sulphate of ammonia ...	275	nil	160	148	333	...
Nitrate of soda ...	308	,,	117	562	371	...
Cinereals and sulphate of ammonia	197	175	181	534	343	...
Cinereals and nitrate of soda	181	nil	256	450	350	...
Cinereals and alternations of sulphate of ammonia and nitrate of soda	190	175	167	484	86	...
Stable-manure ...	317	405	273	411	nil	38
Stable-manure and cinereals	317	455	204	339	,,	229

Limed soil.

	In soil, 1902.	Added in manure.	In soil, 1912.	Removed in produce.	Rendered available from soil.	Rendered insoluble in soil.
Not manured	376	nil	181	282	87	...
Cinereals only	627	175	204	338	...	260
Sulphate of ammonia ...	334	nil	136	474	276	...
Nitrate of soda... ...	327	,,	117	586	376	...
Cinereals and sulphate of ammonia	275	175	204	585	339	...
Cinereals and nitrate of soda	136	175	136	486	315	...
Cinereals and alternations of ammonia and nitrate of soda ...	265	175	153	457	70	...
Stable-manure... ...	317	405	181	435	...	106
Stable-manure and cinereals	nil	455	228	354	...	190

For the full period the records are :—

1891-1912. Soil not limed.

	In soil, 1891.	Added in manure.	In soil, 1912.	Removed in produce.	Rendered available from soil.	Rendered insoluble in soil.
Not manured	228	nil	113	547	432	...
Cinereals only	,,	330	181	579	202	...
Sulphate of ammonia...	,,	nil	160	822	754	...
Nitrate of soda... ...	,,	nil	117	726	615	...
Cinereals and sulphate of ammonia	,,	330	181	920	543	...
Cinereals and nitrate of soda	,,	330	256	842	540	...
Cinereals and alternations of ammonia and nitrate of soda ...	,,	330	167	872	540	...
Stable-manure	,,	1,245	273	771	...	429
Stable-manure and cinereals	,,	1,295	204	703	...	616

Limed soil, 1891-1912.

	In soil, 1891.	Added in manure.	In soil, 1912.	Removed in produce.	Rendered available from soil.	Rendered insoluble in soil.
Not manured	228	nil	181	566	519	...
Cinereals only ...	,,	330	204	714	360	...
Sulphate of ammonia	,,	...	136	907	815	...
Nitrate of soda ...	,,	...	117	845	734	...
Cinereals and sulphate of ammonia	,,	330	204	1,047	713	...
Cinereals and nitrate of soda	,,	330	136	941	519	...
Cinereals and alternations of ammonia and nitrate of soda ...	,,	330	153	906	591	...
Stable-manure ..	,,	1,245	181	870	...	422
Stable-manure and cinereals	,,	1,295	228	810	...	485

The results prior to 1902 suggested that cultural operations had set free from the soil potash soluble in 1 per cent. citric acid solution to an extent greater than the crop demands for potash during the period. But this has not been the case during the second period, or over the whole period. The proportions found soluble in 1 per cent. citric acid have, on the whole, considerably diminished from what they were in 1902, and are now less than they were at the inception of the experiments in 1891. The means are :—

	Per cent.			Pounds per acre.		
	1891.	1902.	1912.	1891.	1902.	1912.
Not limed	·0097	·0123	·0072	228	289	169
Limed	·0097	·0148	·0073	228	348	171

The great demands of the sugar-cane for potash have been met from the reserves in the soil which in 1891 were not soluble in one per cent. citric acid solution.

SECTION FALLOWED WITH NATIVE HERBAGE AS COVER-CROPS.

On this section there are plots which have not received any manure; others which have not had any potash in manures during the course of the trials although manured with sulphate of ammonia and phosphates; and plots which have been manured with potash in addition to phosphates and sulphate of ammonia. The analytical results are as under :—

	1891.		1902.		1912.	
	Per cent.	Pounds per acre.	Per cent.	Pounds per acre.	Per cent.	Pounds per acre.
No manure	·0097	228	·0150	352	·0037	87
No potash	·0097	„	·0155	364	·0087	204
With potash	·0097	„	·0102	240	·0094	220

The records in pounds of potash per acre of the plots are as follows:

1902-1912.

	In soil, 1891.	Added in manure.	In soil, 1912.	Removed in produce.	Rendered available from soil.
No manure	352	nil	87	327	62
No potash	364	„	204	478	318
With potash	240	150	220	489	319

1891-1912.

	In soil, 1891.	Added in manure.	In soil, 1912.	Removed in produce.	Rendered available from soil.
No manure	228	nil	87	747	606
No potash	364	„	204	933	909
With potash	228	256	220	931	667

The results on this section are similar to those recorded from the other section; the plants' requirements for potash have been largely met from the reserves in the soil, which at the inception of the experiments and in 1902 were not soluble in one per cent. citric acid solution.

THE CITRIC ACID SOLUBLE OR 'AVAILABLE' LIME OF THE SOIL.

The readily available lime has been determined by treatment of the various samples of soil with one per cent. citric acid solution. The soil in 1891 contained ·1039 per cent. of lime thus soluble. The following table shows the available lime as determined in the groups of the not-limed and limed plots:—

	Original soil,	Not limed,		Limed.	
	1891.	1902.	1912.	1902.	1912.
Not manured	·1039	·0872	·0843	·1219	·1355
Cinereals only	„	·0733	·0760	·1123	·1123
Sulphate of ammonia... ...	„	·0903	·0802	·1229	·1166
Nitrate of soda	„	·1180	·1060	·1503	·1480
Cinereals and sulphate of ammonia	„	·1102	·0722	·1443	·1016
Cinereals and nitrate of soda	„	·1172	·0631	·1393	·1053
Cinereals and alternations of ammonia and nitrate of soda	„	·1137	·0887	·1418	·1111
Stable-manure...	„	·0903	·0802	·1229	·1166
Stable-manure and cinereals	„	·0903	·0755	·1229	·1065

Owing to the low contents of lime in the sugar-cane no advantage will be gained by considering the records in full detail. They are summarized as follows :—

	Pounds of lime per acre.				
	Soil not limed. 1902-1912.				
	In soil, 1902.	Added in manure.	In soil, 1912.	Removed in crop.	Lost from soil.
No manure	2,049	nil	1,981	67	1
Nitrogen only	2,447	„	2,188	118	141
Manures containing lime	2,315	925	1,863	97	1,280

Pounds of lime per acre.

Limed soil. 1902-1912.

	In soil, 1902.	Added in manure.	In soil, 1912.	Removed in crop.	Lost from soil.
No manure ...	2,854	nil	3,184	68	nil.
Nitrogen only ...	3,210	„	3,110	119	„
Manures containing lime	2,812	925	2,559	103	1,075

Pounds of lime per acre.

Soil not limed. 1891-1912.

	In soil, 1891.	Added in manure.	In soil, 1912.	Removed in crop.	Lost from soil.
No manure ...	2,440	nil	1,981	160	299
Nitrogen only	„	„	2,188	256	nil.
Manures containing lime	„	1,536	1,863	235	1,878

Limed soil. 1891-1912.

No manure ...	2,440	7,200	3,184	68	6,388
Nitrogen only ...	„	„	3,110	293	6,237
Manures containing lime	„	8,736	2,559	270	8,347

These results require consideration in connexion with the indications supplied by the composition of the soil-waters. It was found in 1908-9 that the proportions of lime in milligrams of lime per litre of the soil-waters of certain plots were :—

Milligrams per litre.

	Plots not limed.	Limed plots.
Not manured	280	369
Manured with sulphate of ammonia and nitrate of soda	508	370

These figures are to some extent only confirmatory of the result of the soil-examinations. They show a higher content of lime in the soil-waters from unmanured land which had been limed than in those from not-limed unmanured land ; the soil-waters from the manured not-limed land are higher in their content of lime than are those from not-manured land ; whilst the lime-content of the soil-waters from manured and not-manured limed land are practically identical.

The great loss of 'available' lime from the soil of the limed plots appears to have been mainly due either to loss by surface washings, or to the lime being carried into the deeper layers of the soil, or to a large proportion of the lime being retained in the soil in the form of silicate. The original soil in 1891 yielded ·326 per cent. of calcium oxide (lime) to boiling 20 per cent. hydrochloric acid, whilst a sample of it examined in 1912 yielded ·343 per cent. : the mean content being ·3345 ; the limed soil in 1902 yielded ·3185 per cent. and in 1912, ·294 per cent. The amount of lime added per acre in 1891 would have increased the percentage of lime soluble in hydrochloric acid present in the soil at that time to a mean content of ·626 per cent. The losses of the lime from the soil have evidently been due to drainage of the surface soil into the small surface field drains.

At the end of the first period of the trials there were indications that the lime added to the soil in 1891 had somewhat increased the solubility in one per cent. citric acid solution, of the potash of the soil. At the end of the second period, the mean content in 'available' potash of the not-limed and limed soils are almost identical—·0072 and ·0073 per cent. respectively. But the soil on the limed plots has supplied more potash to the produce from the land during the twenty years period than has the not-limed soil, the proportions being 593 and 318 lb. respectively.

EFFECTS OF THE VARYING TREATMENT OF THE SOIL, OF THE MANURE, AND OF THE LIME, ON THE COMPOSITION OF THE JUICE OF THE CANE.

It is not feasible here to detail the great mass of figures we have gradually accumulated in relation to this question. At the expiry of the first period of the experiments in 1902 we summarized our experience as follows :—

'The results confirm those of previous experiments that neither the addition of phosphoric acid, of potash, nor of lime to the manures favourably affects the sugar-content of the juice of the canes. The effects of the nitrogenous manurings appear to be to somewhat retard the maturation of the canes and thus the juice of canes manured with them is as a rule not so rich in saccharose as is that of canes grown without manure. But this effect is far more than offset by the larger yields of produce resulting from the application of nitrogenous manures and to the fact that the increases produced by the nitrogen are principally due to the development of the stalks in length and in bulk and not to abnormal increases in the amounts of tops and leaves or the production of new shoots to the stool. In this the effects of nitrogenous manures on the sugar-cane are very similar to those on others of the Gramineae.'

The second period of the trials has fully confirmed these conclusions and accentuated their correctness and general reliability. Better cultivation, improved drainage, fallowing with cover crops, liming, and the use of manures, each and all tend materially to increase the yield of sugar-cane from the soil, but there is no evidence that they, independent of meteorological conditions, affect either the saccharine strength of the canes or the purity of their juices. Variety of cane, nature of the soil on which it is grown, irrigation of the land, and the prevalent meteorological conditions are the factors which govern the composition of the sugar-cane and of its juice.

THE INFLUENCE OF THE CULTIVATION, THE LIMING, AND THE MANURINGS, ON THE MECHANICAL CONDITION OF THE SOIL.

With the view of getting some insight into the influence, if any, of the general treatment, the cultivation, the liming, and the manures on the texture of the soil, a modified form of Nobels' automatic soil-washing apparatus was devised, which with the alluvial soils of British Guiana gives very closely agreeing results in duplicate samples. For instance, the following results were obtained with three pairs of samples (A, B, and C) taken in 1912 of the soil of the Experimental Fields, which had been under similar treatment :—

	Sand over 1 mm.	Coarse sand.	Fine sand.	Coarse organic matter.	Coarse silt.	Fine silt.	Humus.	Clay.	Moisture.
A	nil	8·6	6·5	1·2	8·9	8·3	1·2	58·3	7·0
A 1	·1	8·0	6·9	1·2	6·6	7·1	1·1	62·0	7·0
Mean A&A 1	·05	8·3	6·7	1·2	7·7	7·7	1·15	60·1	7·0
B	·1	9·9	5·0	1·3	6·1	5·7	·8	64·0	7·0
B 1	·1	8·6	5·1	1·3	5·5	5·4	·8	66·2	7·0
Mean B&B 1	·1	9·3	5·0	1·3	5·8	5·6	·8	65·1	7·0
C	·1	11·7	5·6	1·6	7·4	7·5	·8	58·2	7·0
C1	·3	10·3	7·5	1 5	7·8	6·5	·8	58·3	7·0
Mean C&C 1	·25	11·0	6·6	1·5	7·6	7·0	·8	58·3	7·0

Still closer agreements were found in the cases of duplicates taken from a single sample.

The following gives the results of the mechanical examination of the soil from groups of plots under various treatment :—

Dry soil, 1912.

	Sand.			Silt.				
	Over 1 mm.	Coarse.	Fine.	Coarse.	Fine.	Coarse organic matter.	Humus	Clay, etc.
Original soil, 1891 ...	nil	7·7	5·9	7·0	5·4	1·2	1·4	72·4
Bare-fallowed section.								
Not limed.								
No manure	·1	7·6	5·8	7·9	4·9	1·3	·9	71·5
Cinereals	·2	6·0	5·5	9·5	7·5	·7	·8	70·1
Sulphate of ammonia	nil	10·1	6·6	7·3	4·9	1·4	1·0	69·7
Nitrate of soda ...	·1	11·2	6·2	8·2	7·1	1·5	1·0	64·7
Cinereals and sulphate ammonia of	·1	9·4	6·4	7·3	6·4	1·2	·9	68·5
Cinereals and nitrate of soda	.2	11·1	7·4	8·5	9·0	1·6	·7	61·5
Stable-manure ...	·2	10·4	5·5	6·2	5·9	1·5	·9	69·4
Limed, 1891.								
No manure	·1	7·5	6·4	9·5	6·3	1·0	·6	68·6
Cinereals	·1	9·0	5·3	6·6	6·1	1·6	·7	70·6
Sulphate of ammonia	·1	12·0	5·3	7·0	5·5	1·5	1 0	67·6
Nitrate of soda ...	·1	13·8	7·6	8·7	8·1	1·8	·9	59 0
Cinereals and sulphate of ammonia	·2	12·7	5·9	6·8	6·2	1·6	·9	65·7
Cinereals and nitrate of soda	·2	12·0	5·7	7·3	6·3	1·5	·6	66·4
Stable-manure ...	·3	11·0	7·0	8·2	7·5	1·7	·8	63·5
Section fallowed with native herbage as cover crops.								
No manure	·1	8·9	6·8	7·6	7·7	1·4	1·0	67·5
Cinereals and sulphate of ammonia	·1	9·3	5·8	6·8	7·3	1·2	1·0	68·5

In making the mechanical analyses great care was taken not to break down the natural or acquired texture of the particles of the soil. The samples were prepared for the Nobel's apparatus by being continuously but gently shaken from two to three hours in a mechanically driven shaking-machine. Hence among the particles termed 'sand' in the analyses are included, in addition to grains of true sand, particles of secondary hardened material not actually sand, but which from their dimensions exercise a similar effect to sand on the properties of the soils. The pro-

portions of the soil present as clay are uniformly less in the cultivated soils than in the original soil which when sampled in 1891 had been long out of cultivation. The average contents of clay found are as follows :—

Original soil	... ..	72·4 per cent.
Not-limed soil	... ...	67·9 „
Limed soil ...	... ...	65·9 „

We are thus justified in concluding that the cultivation has resulted in some amelioration of the texture of the soil.

The differences between the not-limed and limed soils, although indicating an improvement in the texture of the limed soil, are not sufficiently marked or uniform enough to justify the consideration of the results from individual series of plots.

In the hope of ascertaining the effects in the soils of the various manurial treatments, the analyses are grouped below as the means of the not-limed and limed plots, whilst the constituents of the soil are thrown into the three main groups of 'sand', 'silt' and 'clay':—

	Sand.	Silt.	Clay.
Original soil	13·6	12·4	72·4
Not manured with nitrogenous manures	13·4	14·6	70·2
Manured with sulphate of ammonia	17·4	12·9	67·9
Manured with nitrate of soda ...	18·9	15·8	62·9
Manured with stable manure ...	17·2	13·9	66·5

There are well-marked indications of possible coagulation and induration of the soil-particles, due in part to the operations of tillage, and in the cases of applications of nitrogenous manures apparently to the action of the nitrogenous manures themselves. In addition there may have been a sorting-out of the particles of the soil under the action of the nitrogenous manures by which considerable proportions of the finest 'clay' have been either washed away by surface-drainage, or carried into the deeper

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The 'sands' of the various samples, other than those of the original soil, examined were mixed together and regraded. The heavier parts of them were separated by means of a heavy solution (Sonstadt's). Nine-tenths of the particles which had a specific gravity of over 3 were found to be strongly attracted by a magnet. These grains were examined and were found to consist mainly of clay cemented by oxide of iron or 'iron-rust' round minute grains of metallic iron. Common-sense points out that the iron might have been worn off the agricultural tools in use; scientific hypothesis might suggest a cosmical origin for these metallic particles.

layers of the soil. It is not possible for us at the present time to determine which has been the major cause of the change in texture, but future investigations will be planned in the hope of elucidating this.

In the land which had been under cover-crops, the general results of the examinations of the groups are :—

	'Sand.'	Silt.	Clay.
Not manured	15·8	15·3	67·5
Manured with sulphate of ammonia...	15·2	14·0	68·5

Here no alteration in texture of the soil-particles due to the action of the nitrogenous manure is noticeable. It is thus possible that this may indicate that the alteration of the land which had been bare-fallowed on two occasions since 1900 has been largely due to the washing-away of the finest clay during these periods of fallow.

Resume.

The following are the general deductions as to the action of the manures and of the lime upon crops of sugar-cane grown upon very heavy clay lands under the climatic and meteorological conditions existing at the Experimental Fields of the Botanic Gardens from June, 1891 to June 1912 :—

1. Nitrogen in the forms of sulphate of ammonia, nitrate of soda, nitrate of potash, nitrate of lime, nitrolim, dissolved guano, raw guano and dried blood exerts a favourable influence upon the yield of the sugar-cane, and is without doubt the manurial constituent which mainly governs the yield of that plant. This applies to every variety of sugar-cane which has been under trial.

2. When applied in quantities capable of supplying not more than 40 to 50 ℔. of nitrogen per acre, in ordinary seasons there is practically no difference in the effects of sulphate of ammonia, dissolved guano, and of nitrate of soda, but, on the whole, the first is the preferable manure to apply. Nitrate of lime, nitrolim, dried blood and raw guano appear to be inferior to these. In the earlier crops of the experiments the best results were obtained by a mixture of one third nitrate of soda and two-thirds sulphate of ammonia ; but during the latter years this mixture did not prove more efficacious than did either sulphate of ammonia or nitrate of soda alone.

3. Where applied in quantities supplying more than from 40 to 50 ℔. of nitrogen per acre, dissolved guano and sulphate of ammonia are the best sources of nitrogen for the sugar-cane on the alluvial soils of British Guiana. But the latter is the more economical for application.

4. The sugar-cane makes more effectual use of the nitrogen supplied by 250 ℔. of sulphate of ammonia and by about 300 ℔. of nitrate of soda per acre, than it does of that supplied by the heavier dressings. On the whole, dressings of from 2 to 3 cwt. of

sulphate of ammonia per acre appear to be the most certainly profitable applications of nitrogen, although in favourable seasons the use of still higher proportions has proved successful.

5. The application of phosphate of lime to the sugar-cane gives somewhat increased yields when used with manurings of nitrogen and potash. The increases are higher when the applications are made to plant-canes than when added to ratoons. Manurings with superphosphate of lime or with other manures containing phosphates should be restricted to plant-canes, the ratoons being manured with nitrogenous manures only. But the values of the increases in yields obtained by the application of phosphates, except perhaps during the first two or three crops after the land has been placed under cultivation, are not remunerative.

6. Superphosphate of lime appears to be the best form of phosphate to apply to long-cultivated cane-lands which have their subsoil waters alkaline. New lands are preferably treated with 'basic superphosphate' or with slag-phosphate, the former of these in our trials having given somewhat the better results. But slag-phosphate is lower in price and hence is more economical to use. Mineral phosphates to give increased yields must be applied to the soil in such very heavy dressings that their use is decidedly unprofitable.

7. The addition of potash when applied either as sulphate of potash or as nitrate has exerted little, if any, effect. The normal weathering of the constituents of the soil sets free for each crop potash in excess of the quantity necessary for the requirements of the plants. This holds good under ordinary conditions of cultivation, where the greater proportion of the potash taken up by the plants is directly returned to the soil; but where the canes and cane-tops are removed from the land, as in nurseries for the supply of cane plants, it is probable that partial potash-exhaustion will take place in the course of a very few crops.

8. The use of lime resulted in largely increased yields during the earlier years of the trials. But whether or not its use results in profitable increases depends on the price of sugar. Its action is principally mechanical in improving the texture of the land, and it is a question of much importance whether this effect could not be obtained more profitably, and at a lower cost by the use of light ploughs or cultivators.

9. Land fallowed from cane-cultivation and allowed to become overgrown with indigenous, largely leguminous, herbage for a period of about three years, has shown in comparison with similar land under continued cultivation with short periods of bare fallow, a marked improvement in its tilth, and in its contents of humus and combined nitrogen.

THE EFFECTS OF LONG-CONTINUED CULTIVATION AND APPLICATION OF MANURES UPON THE LAND.

10. The soils of fertile heavy clay sugar-cane-lands of British Guiana are, as a rule, slightly to markedly alkaline in reaction.

11. This alkalinity is one of the reasons why sulphate of ammonia usually gives better results than does nitrate of soda.

where these manures are applied in heavy dressings. It enables nitrification to take place very readily in the soil during the existence of favourable meteorological conditions. The alkaline state of the soil replenished by that of the subsoil-waters brought up by capillarity during dry seasons enables sulphate of ammonia to be used year after year without injuring the soil by making it sour.

12. The alkalinity of the soil-waters is increased by cultivation of the land, with its attendant increased plant-growth, and by the action of some chemical manures on the soil. In the course of long-continued cultivation the alkalinity of the capillary water of the soil tends to become excessive, with consequent falling off in the crops.

13. The marked alkalinity and the high content of salts of magnesium and of sodium chloride of the ascending subsoil water act detrimentally on growing crops during dry seasons, and may be the cause of much of the cessation of active growth, of the wilting, and of the scorching of crops soon after the commencement of and during the dry season.

Where the soil contains much organic matter undergoing active oxidation, the soil-water during its concentration remains saturated with carbonic acid gas, and its evaporation takes place into an atmosphere of that gas. Under these conditions, the salts of lime present in the soil-waters are retained in solution until the water approaches its point of saturation, and they beneficially modify the toxic action of the magnesium salts and the sodium chloride on the plants. Where the soil is deficient in organic matter the lime-salts of the soil waters are thrown out of solution at a comparatively early stage of concentration, and on such soils the toxic action of the magnesium salts become very marked during dry seasons.

14. The long-continued use of nitrate of soda in heavy dressings acts detrimentally on the flocculence of the clay in the heavy clay-soils and tends to reduce more or less permanently the productivity of the soil. This effect appears to be due to changes in the layers of soil immediately beneath those to which cultural operations usually extend, and may be remedied by deep and thorough forking of the soil.

15. The growth of sugar-cane without the use of nitrogenous manures is accompanied by marked losses of the combined nitrogen, and of the humus-constituents of the soil. Where nitrogenous manures were used, the loss of nitrogen was increased ; whilst the loss where nitrate of soda was the manure used was somewhat less than where sulphate of ammonia was applied. On the other hand, the loss of humus was much less with sulphate of ammonia than with nitrate of soda.

16. The combined nitrogen and the humus-constituents which accumulate in the upper layers of the soil during long periods of fallowing while the land is covered by dense growths of sedges, grasses, and leguminous plants, suffer great and rapid losses when the soil is put under intensive sugar-cane cultivation, and it is to the loss of the accumulated stores of readily available nitrogen that the marked falling-off in the

yield of canes per acre, which is almost invariably noticed when successive crops are taken off from either new or from from long-rested soils, is due.

17. The system followed in British Guiana of manuring with sulphate of ammonia, with or without potash and phosphates, as the needs of the plantation suggest, with intervening resting or fallowing from cane-cultivation during which the land becomes covered with native herbage, largely leguminous, is one accompanied by conservation and possibly increment of the nitrogen and of the humus-constituents of the soil.

18. During the first period of the trials there was an apparent loss of nearly 40 per cent. of the phosphoric anhydride of the soil soluble in one per cent. citric acid. In the second period, during which greatly improved drainage has been in operation and the tillage has been more perfect, the proportion of phosphoric anhydride soluble in one per cent. citric acid has increased, and where phosphatic manures have been continuously applied, the proportion of 'available' phosphoric anhydride in the soil has been considerably added to.

19. British Guiana sugar-cane soils which contain more than ·007 per cent. of phosphoric anhydride soluble in 1 per cent. citric acid solution by five hours' continuous shaking will not as a rule respond to manurings with phosphates, whilst it is doubtful if soils yielding, under similar conditions, from ·005 to ·007 per cent. of phosphoric anhydride, will benefit by phosphatic manurings. If the soil yields less than ·005 per cent. of phosphoric anhydride, it is advisable to apply heavy dressings of slag phosphate, or lighter ones of superphosphate, or of so-called 'basic superphosphate.'

20. Results prior to 1902 suggested that cultural operations set free from the soil potash soluble in 1 per cent. citric acid solution to an extent greater than the crop demands for potash. The results of the second period and of the whole period do not confirm this view. The proportions soluble in one per cent. citric acid have diminished during the trials and are now less than they were at the inception of the experiments in 1891.

The great demands of the sugar-cane for potash are met from the reserves in the soil which are not soluble in one per cent. citric acid solution.

21. British Guiana soils which yield ·006 per cent. of potash to 1 per cent. citric acid solution, can be regarded as containing, under the usual system of cultivation, sufficient 'available' potash for the needs of the sugar-cane. If the soil yields from ·005 to ·006 it is doubtful if the application of potash salts will result in remunerative returns. Where the yield falls below ·005 per cent., it is advisable to add potash salts in the manures.

22. The demand of the sugar-cane for lime as a plant-food is low, and if the soil gives up more than ·006 per cent. to the one per cent. citric acid solution, it probably will yield sufficient for plant-food for ordinary crops of sugar-cane. The cultivation of the sugar-cane is accompanied by loss of available lime from the surface-soil. This is the greater in proportion to the

amount of lime originally present in the soil, or added in the manures, or applied as lime for the amelioration of the land. Even where applied in very large quantities, the added lime is practically entirely removed from the surface-soil in the course of twenty years.

23. Neither improved methods of cultivation, nor liming the land, nor the use of manures, affects the proportion of sugar contained in the sugar-cane.

24. Long-continued cultivation tends to ameliorate the texture of heavy clay land. The judicious use of natural and artificial manures increases this effect, the upper layers of the soil tending to become, as far as the texture of the particles is concerned, lighter. But this may be and possibly is frequently offset by the great reduction during the cultivation in the quantity of humus-matters present in the soil.

PART V. VARIETIES OF SUGAR-CANE.

Varieties and Their Deterioration.

The Government experiments with varieties of sugar-cane in British Guiana commenced in 1882. During the earlier years sugar-canes of many varieties were introduced from various parts of the tropics and were grown side by side for the purpose of botanical comparison It was soon found that varieties of the sugar-cane were received from various countries under different names and, therefore, efforts were directed towards the solution of synonomy in the nomenclature of the sugar-cane. Laboratory tests were continuously made from the first of canes raised from every imported kind. Later, comparative field-trials with them were instituted. In all, over eighty so-called varieties of sugar-cane were collected together, and these were finally grouped under forty-four names. Experience has shown that the nomenclature of the sugar-cane thus established and first published in the Report on the Agricultural Work in British Guiana in 1890 is, with perhaps one or two exceptions, the accepted nomenclature for sugar-cane in the sugar world.

The cultivation of these old varieties continuously on practically the same land, however, had its drawbacks, as it was found that many of the varieties deteriorated very rapidly under the conditions peculiar to the Experimental Fields and thus several of them were from time to time lost to the collection. In 1890 the following varieties formed the collection :—

Batramic	Jamaica Elephant	Red Ribbon
Boisrouge	Kamba-Kamba-vati	Russell
Bourbon	Kara-kar-awa, No. 1	Sacuri
Brekeret	Kara-kar-awa, No. 2	Samuri
Chigaca	Keening	Selangore
China	Keni Keni	Singapore
Dama	Ko-poa-pa	Tamarind
Driard	Lakona	Vagabonde
Elephant	Large Green	Vico

Grande Savanne	Mani	Violet Ribbon
Green Ribbon	Meligeli	Vitua-huala
Hillii	Nora Tava	Vulu-Vulu
Honolulu	Po-a-ole	West Indian Creole
Horne	Purple Transparent	White Transparent

The varieties 'Samsara' and 'Yuba' were added later.

In 1899 a list of varieties that had died out, was made, when the following were found to be those missing :—

Batramic	Jamaica Elephant	Singapore
China	Keening	Vagabonde
Dama	Keni-Keni	Violet
Driard	Ko-poa-pa	Vitua-huala
Grande Savanne	Large Green	Vulu-vulu
Hillii	Russell	

These varieties died out from several causes. Some were not suited to the soil-conditions at the cane fields; others were unable to withstand the very dry weather that usually prevails on the coastal region of the Colony in the months of August, September, October and November; others ratooned very badly; whilst yet others suffered from disease and were lost from its effects.

Of the collection of over eighty so-called varieties of sugar-cane, the following are under cultivation at the present time :—

Boisrouge	Kara-kar-awa No.1	Samuri
Bourbon	Mani	Selangor
Brekeret	Meligeli	Tamarind
Chigaca	Nora Tava	Vico
Elephant	Po-a-ole	West Indian Creole
Green Ribbon	Purple Transparent	White Transparent
Honolulu	Red Ribbon	Yuba
Horne	Sacuri	
Kamba-kamba-vati	Samsara	

Despite our efforts nineteen varieties have died out since 1890. None of these varieties have been thrown out of cultivation. They have received similar treatment to plant canes and to ratoons on sugar-estates in the Colony, but have not perhaps been so highly manured with nitrogenous manures. As a rule they have received either Ohlendorff's Dissolved Peruvian guano at the rate of 300 ℔. per acre per annum, or sulphate of ammonia at the rate of from 150 ℔. to 200 ℔. per acre per annum. They have been replanted every few years, and thus it may be accepted that they have been under estate-treatment. Is this loss of nearly half of the varieties from a collection not of significance? The deterioration of the Bourbon variety and of many of the seedling varieties of sugar-cane has been remarked by every Sugar Planter in British Guiana and probably in every one of the British West Indian sugar-cane growing colonies, but our experience as above indicated shows that this deterioration is not confined to the Bourbon and to certain seedling varieties.

The gradual falling off in yields of the Bourbon cane commenced in 1896 and became very appreciable in 1904. The yields of the White Transparent variety have also fallen off rapidly and this variety is now cultivated only to a small extent. The following table shows the acreages under cultivation, and the yields in tons of commercial sugar per acre of the Bourbon and White Transparent varieties as reported annually to the Board of Agriculture since 1901 :—

Year.	Bourbon.		White Transparent.	
	Acreage.	Yields.	Acreage.	Yields.
1902	66,048	1·76	1,899	1·86
1903	63,675	1·86	2,786	1·64
1904	60,977	1·64	2,876	1·26
1905	56,137	1·61	1,796	1·41
1906	50,910	1·71	1,416	1·30
1907	45,626	1·53	1,043	1·40
1908	38,134	1·76	637	1·37
1909	30,324	1·79	572	1·39
1910	28,823	1·66	357	1·56
1911	24,252	1·57	251	1·37
1912	22,403		203	

The White Transparent variety has shown itself to be entirely unsuited for growth on the heavier sugar-cane soils of the Colony, and there are only very few of its seedlings which have proved themselves worthy of extended cultivation for longer than a few years on the majority of the sugar estates. The White Transparent gave at the commencement of its cultivation satisfactory yields as plant-canes, but subsequently failed as ratoons. On account of this character, the variety was held by sugar planters to be unsuited to the methods of cultivation in the Colony and was rapidly discarded. The most promising of its seedlings, D. 109, was a general favourite in 1906 and 1907 when nearly 12,000 acres of it were cultivated. It was however found to ratoon very badly and the returns rapidly fell off, especially on the heavier clay soils. The acreage return under D. 109 for 1912 is only about 2,500 acres. The variety still gives good returns, in some cases as much as 2·2 tons per acre, on new lands, especially those of a pegassy

nature, and it is to these lands that it is now almost entirel y confined.

The acreages and the yields in tons of commercial sugar per acre of D. 109 compared with those of D. 625 and D. 145 as recorded from 1901 are given in the following table :—

Year.	D. 109.		D. 625.		D. 145.	
	Acreage.	Yields.	Acreage.	Yields.	Acreage.	Yields.
1901	Not recorded	1·91	Not recorded	2·95	Not recorded	2·17
1902	1,727	2·14	79	2·52	442	2·17
1903	2,583	2·09	191	2·66	644	1·88
1904	3,338	1·78	537	1·94	902	1·74
1905	5,491	1·88	1,445	2·20	1,316	1·92
1906	8,386	1·59	3,357	1·86	1,842	2·06
1907	11,184	1·56	6,600	1·72	2,403	1·72
1908	9,908	1·56	9,664	2·02	3,284	1·90
1909	6,896	1·59	13,564	2·11	3,710	1·91
1910	4,063	1·57	16,650	1·80	4,229	1·76
1911	3,261	1·48	21,672	1·73	4,382	1·73
1912	2,548	...	23,669		4,618	

Extended trials with many seedlings of White Transparent parentage have shown that this variety produces seedlings the majority of which are unsuited to our needs. Some of them have given promising returns as plant-canes and sometimes as first ratoons, but they have subsequently given very small returns and have therefore been held to be unsatisfactory, as the sugar industry generally of the Colony demands varieties that can be successfully cultivated up to third or even fourth ratoons. Of late years considerable importance has been attached by planters in the Colony to the parentage of the varieties they are asked to try on their estates, and for the past three seasons no seedlings have been raised from the White Transparent variety, or from any of its seedlings at that time in cultivation. In fact, out of over 200 varieties cultivated on fairly large areas in the Experimental Fields, only sixteen are of White Transparent origin, whilst out of fifty-six varieties selected as possibly of future value, and which are

now under experimental manurial trials, four only are of such parentage.

The falling off of the Bourbon variety—the old standard sugar-cane of the Colony—as may be seen from the above tables was a gradual one. As pointed out previously, one of the earlier symptoms of 'running out', 'falling off', or 'degeneration' was a reduction in its capacity for responding to treatment with nitrogenous manure. There was also a change in the colour of the foliage and a very apparent falling off in vigour. Subsequently disease (rind fungus of the *Colletotrichum falcatum* type) became prevalent, and about ten years ago rendered the gradual substitution of the Bourbon variety by the hardier seedling varieties advisable. The Board of Agriculture commenced obtaining acreage returns and returns of average yields from sugar estates in 1902. During the period 1902-1912 the acreage under Bourbon has fallen, in round figures, from 66,000 acres in 1902 to 22,400 acres in 1912. During this period the area under seedling varieties has gradually expanded from 4,300 acres in 1912 to over 45,500 acres planted for the crops of 1912. The figures recorded show that the average yields obtained from seedling canes over these large areas during the period have been nearly 11 per cent. in excess of the yields of the Bourbon variety.

With certain varieties, for instance D.625, the lessening vigour of their growth has been attended by increases in their saccharine-content, and in the quotient of purity of their juices. The following table shows the mean results in these respects of the first four years' cultivation of D. 625 on sugar estates as compared with those of the Bourbon on the same estates :—

Expressed juice.

Year.	D. 625.			Bourbon.		
	Specific gravity $\frac{30°}{16·6°}$	Saccharose in lb. per gallon.	Quotient of purity.	Specific gravity $\frac{30°}{16·6°}$	Saccharose in lb. per gallon.	Quotient of purity.
1901	1·0572	1·193	75·7	1·0642	1·442	82·2
1902	1·0626	1·397	81·2	1·0665	1·547	84·7
1903	1·0642	1·423	81·3	1·0660	1·453	80·6
1904	1·0684	1·538	82·3	1·0672	1·539	83·7

The gradual improvement in the sugar-content and purity of the juice of D. 625 was well-marked during these years.

The mean yields in tons per acre of commercial sugar and the characters of the juices of D. 625 and of the Bourbon in 1901 and 1902 and in triennial periods from 1903 to 1911 are shown in the following :—

	D. 625.			
	1901 and 1902.	1903 to 1905.	1906 to 1908.	1909 to 1911.
Commercial sugar, yields in tons per acre	2·74	2·27	1·87	1·88
Juice, specific gravity $\frac{30^\circ}{16·6^\circ}$	1·0599	1·0651	1·0631	1·0605
Saccharose in lb. per gallon...	1·295	1·440	1 370	1·401
Quotient of purity	78·4	82·8	80·0	84·7

	Bourbon.			
	1901 to 1902.	1903 to 1905.	1906 to 1908.	1909 to 1911.
Commercial sugar, yields in tons per acre.	1·97	1·70	1·67	1·67
Juice, specific gravity $\frac{30^\circ}{16·6^\circ}$	1·0653	1·0656	1·0644	1·0647
Saccharose in lb. per gallon	1·495	1·456	1·420	1·447
Quotient of purity	83·5	82·5	80·6	81·1

Whilst the yields of D. 625 have been lower during the triennial periods 1906-8 and 1909-11 than they were in earlier years, the improvements in the composition and characteristics of its juice have been maintained.

Probably the most marked instance of the degeneration of a variety of sugar-cane is D. 78. The records of acreage occupied by it and of its yields in tons of commercial sugar per acre are as follows :—

Year.	No. of plantations on which grown.	Acreage.	Yields.
1902	15	629	1·83
1903	21	846	1·63
1904	19	476	1·64
1905	11	277	1·62
1906	7	179	1·31
1907	5	107	·98
1908	4	34	1·16
1909	3	25	·96
1910	2	14	·68

This cane in the earlier years of its cultivation on sugar estates was credited with producing large yields of sugar and was characterized by very vigorous growth, the stools carrying a relatively large number of canes of fully average size. In the course of a few years under estate-cultivation it changed completely in habit as far as the size of its canes was concerned, degenerating into a grass-like growth of very numerous shoots the majority of which developed little, if any, cane. Its foliage gradually lost its originally deep, almost bluish-green, colouring and its thick, heavy, vigorous looking character, becoming much lighter in hue, its leaves narrower and their ends curling in at their upper extremities. It may be said to have gradually ceased to be readily recognizable as a true sugar-cane.

The falling-off here illustrated must not be confused with the gradual falling-off in yield normal to the cultivation of any variety of sugar-cane where the practice of long-continued ratooning is followed. For instance, supposing 1,000 acres of sugar-cane are to be replaced in the course of seven years by a variety capable of yielding as plant-canes, on an average, 3 tons of sugar per acre, their yield gradually decreasing to one of $1\frac{1}{2}$ tons per acre per crop in the case of fifth and older ratoons, the extension being a gradual one from 10 acres upwards, approximately 17 per cent. of the land being replanted each year, then without any deterioration of the variety having taken place the yield of canes in the course of ten years will decrease from 3 tons of sugar per acre in the first year to about 2·2 tons in the tenth and later years. Should the area be planted to plant-canes, first, second and third ratoons, the yield would fall off to 2·5 tons for the eighth and later years, whilst if only plants, first and second

ratoons were cultivated, the yield would probably fall to 2·7 tons per acre for the same period. It is evident that the falling-off in the cases of deteriorating varieties is at a far higher rate than that due to cultivating increasing areas of ratoons should be.

A considerable area cultivated under seedling canes is on land that will no longer grow profitable crops of the Bourbon variety, so that the figures available as to the value of seedling varieties must be looked upon as minimum figures and not as average ones. Two of us, in 1905, were called into consultation as to the condition of the canes on a certain estate on the Essequibo coast. The Bourbon variety was practically the main variety cultivated. The whole of the Bourbon canes were very seriously diseased, and in fact some fields were so badly affected that the canes were not taken to the mill. The proprietors seriously considered the abandonment of the estate, but by the substitution of seedling varieties, notably D. 625, for the Bourbon variety, the estate has been entirely rejuvenated and is now in a comparatively flourishing condition.

The importance of seedling varieties to the sugar-industry of British Guiana is fully recognized by the planting community and many estates maintain nurseries for the raising of new varieties suited to their respective soil and meteorological conditions.

The falling off or degeneration of the Bourbon variety has greatly exercised the attention of planters and others interested in the sugar-industry of the Colony. It may be assigned to a variety of causes but, in our opinion it would appear that the following five causes are of the greatest importance in the degeneration of the Bourbon cane and other varieties of canes in this Colony :—

(1) Lack of vigour induced by continuous cultivation in the same soil.

(2) Continuous cultivation of the land to the same depth.

(3) No care being taken in the selection of suitable material for planting purposes.

(4) Spread of diseases.

(5) Changes in the varieties themselves.

These probable causes are to a very great extent interdependent. The Bourbon variety does not grow with the same vigour as in former years, even when planted in comparatively new lands, and there has been practically no selection on estates of the best material possible for planting purposes. We have data which undoubtedly indicate that the cultivation of the sugar-cane, as practised in this Colony, viz. to the same depths every year, produces a clay 'hard-pan' which is detrimental to proper drainage and root development. It was thought that possibly a rotation of varieties with differently developed root-systems might meet this cause. Experiments were planned to test this point.

It had been observed in the South Fields of the Experimental Fields at the Botanic Gardens that it was difficult from 1900 to grow the Bourbon variety on parts of the field which

had been occupied by that variety since 1891 while it was noticed in 1905 that on parts of the field where the Bourbon had been replaced by a seedling variety for five or six years and which were then replanted in Bourbon, the crops were fairly satisfactory. The following mean results were obtained from 1905 to 1908 from four contiguous plots planted continuously with Bourbon from 1891, in comparison with four plots which were cultivated in Bourbon from 1892 to 1898, and in D. 78 for the crops 1899 to 1904. The cultivation and manurial treatment were exactly similar on the two series of plots:—

Tons of canes per acre.

	Bourbon after Seedling D. 78.	Bourbon after Bourbon.
1905	25·1	23·4
1906	23·1	22·0
1907	17·5	13·0
1908	25·2	5·0
Mean	22·5	15·8

In 1908 the field was thrown out of cultivation, rested, and very thoroughly and deeply forked so as to break up any 'hard-pan' that might have been formed. More extensive and searching trials were planned to be carried on on it, but since then there has been little difference between the growth of the Bourbon canes on the part of it which has not been under cultivation in Bourbon for several years and on that part which has been under continuous cultivation with Bourbon.

In an earlier part of the paper dealing with the injurious effects of long-continued applications of nitrate of soda to heavy clay-land, the effects of the deep forking in breaking up hard-pan have been noticed.

Up to the present it has not proved feasible on sugar estates in British Guiana to use any system of selection of the tops to be planted. There can be no doubt that when it is found feasible to adopt such a system the yields per acre will be increased, as tops free from disease and from insect-attacks will certainly result in plant-canes of greater immediate vegetative vigour than those grown from diseased or insect-injured tops can have. It is possible that long-continued planting of tops practically without any reliable system of control does in time tend to the production of a strain of sugar-cane more or less defective in vegetative vigour. The careful selection of healthy tops free from any signs of insect and fungoid attack and their treatment before planting with Bordeaux mixture would be worthy of trial on a large scale.

The system of flooding the fields at intervals of a few years is one that is well-calculated to lessen the spread of fungoid disease and insect-attacks, especially of the 'root fungus disease' and of the various borers and other pests that seek refuge in the stools of the cane or in the soil.

But these various cultural defects do not account for such fallings off in yields as we have illustrated in the cases of the Bourbon cane, the White Transparent cane, D. 109 and D. 78, and for the gradual loss of many of the imported varieties despite all our efforts to retain them in our experimental cultivation.

Every experimenter who has raised seedling varieties of canes in large numbers is aware of the fact that out of the large numbers of seeds he may germinate, comparatively small proportions of the plants obtained reach the stage at which they can be planted out. Very many of those raised die in their infancy from no perceptible cause, whilst others survive for a few months or for a very few years, falling off so rapidly in vegetative vigour that they soon cease to exist. It is from all our experience a fair assumption that the length of life—economic life—of varieties of sugar-cane differs very greatly, and that with possibly few exceptions the growth of any variety of sugar-cane year after year on the same land is attended by a grave curtailment of its economic life due to what may be regarded as the 'running out' of the variety, which may be one of the effects of the approach of its senility.

Economic Life of the Cane.

The span of economic life of various cultivated varieties of sugar-cane appears to differ greatly. The normal duration of economic life is longest in the cases of those which as a rule seldom produce pollen, i.e., which are more or less deficient in their powers of reproduction by seminal means, for instance the Red Ribbon and the Purple Transparent canes. But in Java the latter variety, known there as the 'Black Cheribon' and elsewhere as the 'Black Java' cane, has as a concomitant of long-continued intensive cultivation become exceedingly susceptible to 'Sereh'. Until comparatively recent years the Bourbon variety was a sparse producer of seeds, although there is evidence to show that at times it produced seeds in some abundance. Now it is a prolific producer of fertile seeds, and it is possible that this is an indication that it may be suffering from 'running out' due to its senility.

In the case of D. 78 the period of economic life under cultivation on sugar estates was about six years, whilst that of D. 109 on sugar estates has been from about ten to twelve years. It is almost unnecessary to point out that under favourable conditions of growth the duration of useful life of a sugar-cane may be materially lengthened, that a change of soil and environment may brace it to renewed vigour and that whilst a sugar-cane may suffer from 'running out' or senility in one locality it may be in full vigour of life and vegetative

activity in another. We have already indicated that in the case of the varieties that have on many estates in British Guiana attained a condition of running out, that condition is marked by changes in the leaves of the plants, a marked diminution of their power of producing chlorophyll, shown by their lighter colour, tending in some cases towards chlorosis, and by changes in their structure. It appears to us to be indicated that the senility or running out of the cane is attended by changes in the merismatic tissue and in the vein areas of the leaves, and we hope to make this a subject of future investigation. Following the words of H. M. Benedict, modified to suit our present purposes, we believe that in the sugar-cane as in other plants which naturally reproduce themselves by seed and which tend to 'run out' after long-continued vegetative propagation, changes in the vascular system of the plants are due to the increasing senility of the meristem just as changes in the vascular system of animals are due to their senility. It has been said that 'a man is as old as his arteries' and it may be said of varieties of the sugar-cane as of other plants reproduced vegetatively that they are as old as their veins.

An argument which may be adduced in the case of the Bourbon cane against this theory of running-out or senility is that it had been under wide-spread and long-continued cultivation in British Guiana until about 1895 without showing any sign of degeneration. But the records of other sugar-cane growing countries show that the Bourbon cane has run-out in the majority of them and its cultivation has had to be largely curtailed or abandoned. The running-out has occurred after very varying lengths of cultivation in different countries. It occurred in Queensland as long ago as 1872 when the variety had been there in cultivation only a comparatively few years. Its effects commenced to be marked in the northern West Indian islands early in the nineties of the last century, probably preceded somewhat in Barbados where its cultivation had been the most intensive amongst the West Indian Colonies, and followed a little later in St. Vincent where from about 1884 its cultivation had ceased to be intensive.

But are we at all certain that the Bourbon cane of to-day is the Bourbon cane of twenty, thirty, or fifty years ago? Our experience in British Guiana has proved that under certain conditions during the years prior to its becoming a regular producer of fertile seeds in great abundance, at intervals of some years it produced seeds which gave rise to seedlings in some numbers. For instance, in 1897 we obtained considerable numbers of seedlings of the Bourbon variety from canes grown under conditions that rendered cross-fertilization by the pollen of other varieties very improbable if not impossible. Practically all of the varieties obtained had a close resemblance to the Bourbon variety, so close in fact that if their canes were mixed in the field or in the cane-carrier with Bourbon canes it would be exceedingly difficult or rather practically impossible to separate them from the latter canes. It is possible that among the causes that have resulted in the prolonged economic life of the (now) so-called Bourbon variety the addition to it of new strains due to seminal reproduction was not the least. It is in our opinion probable,

that in many places among the fields of sugar-cane now termed Bourbon there are comparatively few, and possibly not any, representatives of the original Bourbon variety, and that the present type of sugar-cane termed Bourbon is a mixture of some of the true Bourbon cane with strains of it due to seminal reproduction. In other words, there exists no longer a cultivation consisting of a pure Bourbon variety. Our fields of Bourbon cane now consist of several closely allied varieties known collectively as the Bourbon cane. This view is well-illustrated by the numerous coloured drawings of the seedling varieties raised by us from the Bourbon cane which have been prepared by Miss van Nooten of our Department.

At present in British Guiana the liability of the Bourbon cane to attacks of fungoid disease is greater at and after the normal arrowing period. Healthy and vigorous Bourbon canes can still be grown on good land for the April and June crop. Whether this will continue to be the case it is not possible to foresee.

The Bourbon cane, even in the years before it commenced to show signs of running-out, was very susceptible to the effects of drought, more especially of intense drought occurring at or about its flowering time. Since then it has become, if possible, even more susceptible to injury by long-continued periods of dry weather; and in many instances such periods have proved more or less disastrous to the crops of Bourbon growing on sugar estates.

We have found that several of the seedling varieties of sugar-cane raised from the Bourbon cane are also susceptible to grave injury by drought: although, as far as our experience has gone, none of them is as susceptible as the Bourbon.

The Production of Seedling Varieties.

In the preceding section we have shown that varieties of the sugar-cane, like other plants which naturally reproduce themselves by seed, tend to 'run out' after long-continued vegetative propagation, in some cases ultimately dying from the effects of senility, whilst in other instances they become very susceptible to fungoid attacks. It is this that renders it necessary for us to develop new varieties from seed to take place of those which have, or are being 'run-out.'

Previous to 1889 attempts at raising seedling varieties of sugar-cane were not successful in British Guiana. Towards the end of December 1889 a few seedling varieties were obtained from seed brought by one of us from Barbados and from seeds of the following of the older varieties then under cultivation at the Botanic Gardens:—

Kara-kar-awa	Samuri
Mani	Vagabonde
Purple Transparent (Meera)	Keening

In the autumn of 1890 and in subsequent years, seedlings in larger numbers were raised from many of the older varieties. The most prolific of these were and still are Kara-kar-awa and Brekeret, very small canes introduced into British

Guiana from Mauritius. It is, in any year, an easy matter to obtain enormous numbers of seedlings from either of these varieties. In the first year (1889) only seeds from Kara-kar-awa germinated, and it is fairly certain from the dates of the sowings that, although our records do not show the actual dates of the appearance of the arrows which were sown, the seedlings obtained from it were the product of self-fertilization. It is the earliest of all the older varieties to flower and to mature its seeds.

The fact that the offspring of Kara-kar-awa, of which we have records, were in all probability the results of self-fertilization and not of crossing with other of the old varieties renders the records of these seedlings of 1889 (which may be found on pages 40 and 41 of the report on the agricultural work in the Botanic Gardens for the year 1890) worthy of careful study. The arrows of the Mani cane which proved fertile in 1889 were sown after all other varieties had ceased to flower, and it is very probable that its progeny was also the result of self-fertilization. The records, which support this conclusion may be found on pages 41 and 42 of the above-mentioned report. In later years the only varieties from which we have obtained fertile seeds and seedlings that could be regarded as certainly self-fertilized have been Brekeret, Kara-kar-awa, and the Bourbon. In 1890 we obtained large numbers of plants from the 'Brekeret' when the ' panicles which produced the largest number of plants of any individual panicle that was sown, flowered, matured and were gathered and sown before the arrows of any other kind were out' (page 30, *loc. cit*). We also obtained from the Kara-kar-awa a considerable number of plantlets from ' panicles that were arrested in the sheath and as they never emerged therefrom no cross-fertilization between the flowers of one variety or another was possible' (*loc. cit.*). Our results thus proved that cross-fertilization was not essential to the fertility of the flowers of certain varieties of the sugar-cane, and showed that the majority—two thirds at least—of the progeny of the self-fertilized varieties, although differing in minor characteristics from the parent plants and from one another, were of obvious affinity as regards colour, size and general characteristics to the parent plants. Others varied in different degrees from the majority, whilst others (but comparatively few) presented extreme variations in colour, in size and in saccharine strength from the parent plants and from one another. It was these results that led the late Mr. G. S. Jenman and two of the authors of this paper not to lay much weight on artificial cross-fertilization of the sugar-cane as a practical method of ensuring its improvement in vegetative vigour and in saccharine strength.

During the earlier years of our trials we directed much attention towards obtaining fertile seeds and seedlings from the Bourbon cane. We failed in this in 1889, 1890 and 1891, we got thirty-six plants in 1892, whilst we failed completely in 1893, 1894, 1895 and in 1896. But in 1897 we obtained thousands of seedlings of the Bourbon cane under conditions which rendered the cross-fertilization of the variety very im-

probable, but we were able to raise only fifty-one of them to the planting-out stage. Of these, No. 4395, 4397, 4399 and 4407 are still under cultivation and markedly resemble, as is shown in Miss van Nooten's drawings, their parent cane. We again failed in 1898, 1899 and 1900; but in 1901 and in each year since, the Bourbon canes on our Experimental Fields have produced very large numbers of fertile arrows from which we could, if we so desired, obtain seedlings in practically unlimited numbers. Our experience with the Bourbon cane as regards variation is similar to that with Kara-kar-awa, Brekeret and Mani recorded during our earlier trials. The physical and cultural characteristics of the majority of seedlings strongly resemble those of the Bourbon although differing from them in many minor points, while relatively few of its progeny differ widely from it in colour, size, and saccharine strength. None of the varieties obtained from the Bourbon up to the present approaches in its important characteristics and in its value as a sugar-producer the Bourbon cane as grown in British Guiana prior to the time it first showed signs of 'running-out'.

It has been our general experience, not alone with the Bourbon but with other varieties, that the arrows of ratoon canes, of canes not highly cultivated, and of canes which attain the arrowing period whilst still of immature growth, are more fertile than are arrows from plant-canes and from canes that are in highly vigorous vegetative growth under intensive cultivation. Of late years, however, we have been able to obtain any quantity of seedlings from the Bourbon cane growing at the Experimental Fields as plant-canes under intensive cultivation. As already pointed out, despite all our efforts, the Bourbon cane no longer flourishes on these fields, and it is probable that during deterioration in the variety increased seed-producing power has ensued.

Our experience with raising seedlings from the Ribbon Canes such as the Red Ribbon or Striped Singapore the Striped Mauritius, etc., has, however, been the reverse of that with the Bourbon. In the earlier years comparatively large numbers of seedlings were obtainable from these varieties, but of late it has been difficult to obtain any. The reason for this is not obvious at the present time, but with further investigation its solution will be forthcoming. The White Transparent, also, which in the West Indian islands is almost completely infertile, is in British Guiana comparatively fertile, and in some years large numbers of seedlings have been raised from it.

When only a small number of varieties, principally the older named ones, were under cultivation at the Experimental Fields arrows were sown from practically every variety. Only comparatively small numbers of seedlings were obtained, as many of the varieties were not very fertile. It was easy to make thorough botanical and chemical analyses of them. It was soon obvious that seedlings raised from Brekeret, Kara-kar-awa, Vico and several others of the older varieties, on account of their very small size, could never be of economic value to the sugar industry of British Guiana. Seedlings were therefore raised from the Ribbon canes, the Purple and White

Transparent canes, the Bourbon and a few other kinds. The results obtained from the seedlings raised were comparatively unimportant. It was found that the arrows of the seedling varieties were much more fertile than were the arrows of the older varieties, and therefore the policy of sowing large numbers of arrows from the earlier seedlings was adopted by the late Government Botanist, Mr. G. S. Jenman, in the hope that out of the very large numbers of plants raised, some, at least would be worthy of selection for estate-trials. This policy however did not give satisfactory results. The seedlings from which the arrows were selected had not been tested for a sufficiently long period of time to indicate their value, and much time was wasted with the examination and testing of very large numbers of kinds raised from seedling-varieties that were themselves quite useless for general cultivation. With the accumulation of evidence in this direction, and as experience was gained, it became evident that the value of a sugar-cane for propagation-purposes must be looked at from a broad and general point of view. Some varieties gave seedlings of which a large proportion were subsequently selected for further trial while other varieties gave hundreds of seedlings out of which only one or two could possibly be selected. By attention to the planting of the seedlings in groups it was found possible to make a general field selection and in this way, it has of late years, been possible to discard very many kinds as being quite useless for propagation-purposes. Although an examination of the individual characteristics as transmitted to the progeny has been closely pursued only since 1907, it has become possible to make some generalizations in regard to the value for breeding purposes of certain varieties cultivated in the colony.

In 1902 a portion of the Experimental Fields was set apart for raising sugar-cane seeds for breeding purposes. The best varieties then under cultivation were planted in alternate rows and also in chess-board fashion and the sowings of arrows were almost entirely confined to arrows from this portion of the fields. The results, however, cannot be said to have been at all satisfactory. This system is similar to that adopted in Java and the trial was laid out in personal consultation with Professor F. A. F. C. Went, then of the West Java Experiment Station. In our opinion this system may be well adapted to situations which are not swept during the arrowing season with very strong winds, but where strong winds prevail it seems that blocks of the several kinds used larger than were supplied by canes planted in alternate rows or singly in chess-board fashion, were desirable particularly as it was found that seldom did the varieties arrow together as wanted. This was specially noticeable with the varieties selected in our Experimental Fields by Professor Went as being those which had given excellent results as the male parents in hybridization with the Cheribon in Java. During six years in no case did these sugar-canes on our fields arrow simultaneously with the White Transparent or Cheribon cane.

Our large-scale variety-manurial experiments in which only the best sugar-canes were cultivated seemed to us to offer

a similar system to the above on a far larger scale where the high winds would have less effect than on the smaller areas and where there would be better chances of at least some of the canes of various varieties arrowing at the same time. During the last five years therefore, our general supplies of seedlings have been raised from the canes growing in these variety-manurial plots. These seedlings are either the results of self-fertilization or are crosses—the male parent being unknown but confined to one of the good varieties growing near by.

The feasibility of obtaining seeds from the sugar-cane by artificial cross-fertilization at the Experimental Fields at the Botanic Gardens has been a matter of frequent discussion. But it has been found that the high, drying winds which prevail at the Experimental Fields during the arrowing season are so inimical to the production of fertile seed under artificial conditions that it would be a waste of time and of work to make attempts towards artificial hybridizations. This view was concurred in by Sir Daniel Morris, K.C.M.G., at his visit to the Experimental Fields in 1907, and we are satisfied as to its wisdom.

It, however, seemed to be worthy of trial to raise seedlings of controlled parentage. In 1907 plots were laid out in the Brickdam field for this object ; in 1909 a further extension of them was made. In these experiments the arrows of two varieties were bagged together and subsequently one arrow was withdrawn. This method is commonly termed the 'Java method' but it is the one devised in the sixties of the nineteenth century by the late W. Drumm of Barbados in the hope of obtaining what he then termed the 'Darwinisation' of the sugar-cane. The seedlings raised from these crossed arrows are either the result of self-fertilization or are the result of crosses, both parents being known. This line of work has been extended during the last three years and now quite a considerable amount of controlled breeding work is being annually done with our varieties of canes. It is too early yet to say what results will be obtained, especially as the last three years have been, on account of the severe droughts prevailing at the arrowing season, unfavourable ones for the raising of seedling-varieties.

In 1908-9 the following probable hybrids were obtained :—

Parentage.	Seeds germinated.	Plants basketed.	Canes selected for planting.
D.625 × D. 95 ...	97	70	65
D.625 × Red Ribbon ...	42	39	5
D.95 × Red Ribbon ...	85	80	76
Red Ribbon × D. 366 ...	40	23	23

From these the following varieties grew with sufficient vigour to be worthy of analytical examination in 1910 and 1911 :—

No. of cane.	Average weight in lb. of one cane.	Expressed juice. Per cent. of cane.	Specific gravity $\frac{30°}{17·5°}$	Pounds per gallon. Saccharose.	Glucose.	Quotients of Purity.	Non-sugar.
	Parentage D.625 × D.95						
8	3·2	60·7	1·065	1·359	·312	76·4	6·1
9	3·0	66·2	1·074	1·550	·250	76·7	10·9
22	4·0	63·7	1·076	1·759	·178	85·1	6·2
25	4·5	68·4	1·075	1·634	·227	80·0	8·9
161	5·9	70·1	1·078	1·892	·048	88·6	8·2
164	7·3	69·6	1·063	1·365	·178	80·5	9·2
176	9·0	67·6	1·064	1·515	·067	86·3	9·9
183	4·9	70·4	1·0695	1·563	·156	82·4	9·3
193	7·0	76·6	1·053	1·068	·216	74·4	12·3
	Parentage D. 625 × Red Ribbon						
32	5·3	63·6	1·072	1·606	·125	86·0	7·7
34	3·5	63·2	1·078	1·858	·119	87·5	6·9
37	5·8	66·5	1·075	1·759	·113	86·1	8·4
38	4·0	62·9	1·077	1·868	·083	88·9	7·1
43	5·2	62·2	1·085	2·050	·096	88·7	7·2
47	7·0	65·9	1·082	1·827	·208	82·0	8·7
188	7·3	66·6	1·078	1·900	·063	89·4	8·1
199	7·4	67·9	1·0735	1·749	·067	87·4	9·3
	Parentage D. 95 × Red Ribbon						
3	5·8	67·7	1·090	2·130	·039	86·8	11·5
156	5·6	66·6	1·065	1·421	·119	79·9	13·4
157	6·6	65·8	1·079	1·894	·050	88·9	9·5

The hybrids of Red Ribbon and D. 366 were of no promise of future value as sugar-canes and were discarded.

The morphological characteristics of the parent varieties D. 625, D. 95 and Red Ribbon, are as follows :—

D. 625.—A seedling of Dyer. itself a seedling of Meligeli. A very large and vigorous cane, in typical instances with cylindrical internodes 10 to 11 cm. in length and about 16 cm. in girth. It is of a clear straw-yellow colour with small reddish yellow blotches in places where exposed to the sun. Its eye-buds are relatively small but broad, round and flat with a pointed apex. whilst its internodes are not channelled.

D. 95.—A seedling of White Transparent (Caledonian Queen strain). A small variety with internodes about 11 cm. in length and about 8·5 cm. in girth : its colour is brownish purple to purple with, in places, a copious white bloom or incrustation. Its eye-buds are flat, broad, and pointed, and are very protuberant; its internodes are channelled.

As a rule its seedlings are very closely allied in their colouring to the parent cane, they not infrequently show in the upper joints the stripings characteristic of the Red Ribbon, whilst some of them tend to revert in very large proportion to the characteristic colouring of that variety. They then resemble stunted Red Ribbon canes.

Red Ribbon.—A very well-known and widely distributed—probably the most widely distributed—old variety. As grown in British Guiana it is of medium size with internodes about 10·5 to 12·5 cm. in length and about 12·5 cm. in girth. In colour it is a clear and bright straw-yellow with dark-red to purple very sharply defined stripings with some white bloom or incrustation in parts. The eye-buds are flat and pointed and are moderately prominent; the internodes are chan nelled.

The morphological characteristics of the principal hybrids of

D. 625 × D. 95

are as follows :—

No. 8.—A somewhat stout cane with internodes averaging 7 cm. in length and 11 cm. in girth ; small, rounded eye-buds : no channel in internodes ; a yellowish green cane with brownish red splashes.

No. 9.—A somewhat stout cane with very long internodes averaging 16 cm. in length and 12 cm. in girth, large somewhat pointed eye-buds internodes with shallow ill-defined channel : the colour of the cane is bright yellow.

No. 22.—A somewhat stout cane with internodes averaging 7 cm. in length and 12 to 13 c.m in girth ; small round eye-buds, no channel in internodes. In colour it is green, passing to bright yellow, or to brownish yellow where exposed to the sun.

No. 25.—A very stout cane with internodes averaging 10 cm. in length and 15 cm. in girth, eye-buds somewhat pointed and very prominent ; no channel in internodes. In colour it is green passing to bright yellow.

No. 161.—A medium-sized cane with internodes averaging 8 cm. in length and 10 cm. in girth ; and pointed eye-buds, well-marked channel along the internode. The cane is olive to bronze-green in colour, changing to bronze where exposed to the sun.

No. 183.—A medium-sized cane with internodes averaging 9 cm. in length and 11 cm. in girth ; eye-bud small and rounded, no channel along the internode. The cane is bright green and yellow in colour.

The more valuable of the hybrids produced by

D. 625 × Red Ribbon

have the following characteristics: —

No. 32.—This hybrid produced a vegetative sport amongst its canes. The majority of the canes are medium-sized ones with internodes about 8 cm. in length and 12·5 cm. in girth, the eye-buds are small and round, there is a somewhat flattened channel along the lower part of the internodes; and the cane is bright yellow in colour. The canes of the sport are larger and the internodes average 12·5 cm. in length and about 12·5 cm. in girth, the eye-buds are very large, pointed and prominent. The canes are a greenish yellow striped with purple and with some white incrustation.

No. 34.—This hybrid produced four vegetative sports amongst its canes. The original hybrid is a fair-sized cane with internodes about 10 cm. in length and 10 cm. in girth ; its eye-buds are broad and rounded, and somewhat prominent ; its internodes are not channelled ; its colour is olive-green passing in places to yellow.

Sport No. 1 is a large cane with internodes about 12 cm. in length and 12·5 cm. in girth, its eye-buds are very small and round ; the internodes are not channelled ; its colour is reddish brown passing in places to brownish yellow.

Sport No. 2 is a medium-sized cane, dull yellow in colour, striped with bright green stripes. Its internodes are about 5·8 cm. in length and about 11·5 cm. in girth. Its eye-buds are rounded and somewhat pointed ; the internodes are not channelled.

Sport No. 3 is very similar in size to Sport No. 2. In colour it is deep yellow with broad green stripes. Its eye-buds are very small and rounded, the internodes are not channelled.

Sport No. 4 is a small cane with internodes about 13 cm. in length and 9 cm. in girth, the eye-buds are rounded, somewhat pointed and prominent, the internodes are channelled. It is of a brown-bronze colour with dull green stripes.

No. 37.—A very bright yellow cane of medium size, internodes averaging 9 cm. in length and 9 cm. in girth, the eye-buds are rounded and pointed, the internodes have well-marked channels.

No. 38.—A deep brown cane of medium size ; the internodes are about 9 cm. in length and about 10·5 cm. in girth ; the eye-buds are pointed and very prominent ; the internodes are not channelled.

No. 43.—This hybrid produced a vegetative sport. The hybrid is a green and yellow cane with some red-brown stains where exposed to the sun. It is of medium size with internodes of about 11 cm. in length and 10 cm. in girth. On some of the joints there are prominences opposite to the eye-buds. The eye-buds are flat and round, the internodes show somewhat flattened channels.

The sport is a somewhat larger cane with internodes averaging 12·5 cm. in length and 10 cm. in girth. It is very dark-green in colour passing to bronze, and in places to purple; its eye-buds are small, round and close to the cane. The internodes are not channelled.

No. 47.—A medium-sized cane of a dark-reddish brown colour with internodes 15 cm. in length and 10 cm. in girth. The eye-buds are round and are rather large. The internodes are not channelled.

No. 188.—This hybrid produced a vegetative sport. Both hybrid and sport are bright yellow canes. The former is somewhat below medium size, with internodes about 8·5 cm. in length. Its eye-buds are rather large, round and prominent. The internode is fairly channelled.

The sport is a very thin cane with internodes about 10·5 cm. in length and about 5 cm. in girth. Its eye-buds are round and are very small; the internodes are not channelled.

No. 199.—A very short-jointed stout cane with internodes averaging 4·5 cm. in length and 13 cm. in girth, the joints being tumid and subject to cracking. Its eye-buds are of medium size and round. Its colour is greenish-yellow with red-brown splashes.

The only hybrid of

D. 95 and Red Ribbon

which is of potential value, has the following characteristics:—

No. 3.—A fairly large cane, dark-yellow to reddish-yellow in colouring with internodes about 10 cm. in length and about 12 cm. in girth. In the middle and lower joints the eye-buds are round, medium in size and close to the internodes, which are smooth and not channelled. In the upper joints the eye-buds are very large and protuberant, whilst the internodes are very deeply channelled. The internodes usually have well-marked prominences opposite to the eye-buds.

The cultural and morphological characteristics recorded of these hybrids show that the tendency to variation, due doubtless to earlier hybridizations of the parent kind, is more marked in them than (with the exception of the Red Ribbon cane) it is with 'selfed' seedlings obtained from their parents.

Our experience indicates that little advance is likely to be made in; raising hybrids of desired characteristics until we have obtained by seminal selection or otherwise, parent-varieties of fixed character and pure descent.

Large numbers of hybrids were raised in 1909, 1910 and 1911; but the long-continued drought of 1911 has prevented their field-

characteristics from being determined. We have, however, to place on record that few canes of promise are among our hybrids of 1909 and 1910.

FERTILITY OF THE POLLEN OF VARIETIES IN BRITISH GUIANA.

The pollen of the several varieties of seedling canes which are cultivated on a large scale in the Experimental Fields together with that of many other varieties was thoroughly tested in 1909, 1910 and 1911 in the hope of finding a variety that yielded only infertile pollen. The search was an unsuccessful one. Even the White Transparent, which in the West Indian Islands possesses practically no fertile pollen, was found in some instances to have quite a large number of fertile grains. The pollen grains were examined microscopically and it was found that the proportion of infertile grains in any variety varied from year to year. The Java iodine method was also used and similarly gave indications that the condition of the flowers of the varieties altered in respect to their pollen from year to year and possibly at different periods of the same season. We are not, however, convinced of the reliabilty in all cases of this iodine test.

Owing to the meteorological conditions in the arrowing season it has not been found possible to continue the cross-fertilization work after emasculation carried on by one of us when stationed in Barbados. The principal varieties have, however, been 'selfed' with the view of obtaining some data in regard to the several unit characteristics of which they are made up. The majority, if not all, of our varieties are of hybrid nature and therefore 'selfing' must be practised before definite information can be gained of the actual constitution of the different varieties. Work on these lines was started by one of us in Barbados and has been continued in British Guiana. Until these data are obtained it will not be possible to apply the principles of the Mendelian theory to the production of hybrid varieties of sugar-cane from seed. Such data are essential to any breeding problem and must be obtained before any real advance can be made. With the present incomplete knowledge of what are unit characteristics in the constitution of the sugar-cane we have to work largely in the dark, and it is essential that some data shall be obtained in the direction indicated. The method of obtaining 'selfed' seedings also has economic possibilities, and close breeding for some years cannot but prove of value especially in cases where the chances of accidental crosses with other less useful varieties are eliminated.

The general methods adopted in the selection of our seedlings have been given at previous Conferences, but perhaps may usefully be re-stated :—

First selection of parent varieties for seed producers ;

Second selection of the more vigorous of the seedlings obtained from them for field propagation ;

Third selection of the varieties growing under field conditions by the cultural characteristics ;

Fourth selection fro n these selected sorts by their analytical characters ;

Fifth selection. The third and fourth methods are repeated with plants raised from the tops of the varieties selected under the fourth selection, and this is done repeatedly during the cultivation of them from plants to second and third ratoons. As the method of cultivation in British Guiana renders it necessary for canes to have good ratooning powers to be of service as sugar producers, we lay more stress on the selection from ratoons than from plants ;

Sixth selection. The varieties which have been selected are next grown on plots of about $\frac{1}{20}$-acre, side by side and under identical conditions of cultivation and manuring. On these their peculiarities are carefully watched, and out of batches of forty or so selected for this trial probably not more than a dozen will be retained in cultivation as third or fourth ratoons ;

Seventh selection. During the course of the fifth and sixth selections several of the varieties finally retained in cultivation will have been selected by planters for large-scale cultivation. These and others selected by ourselves are next examined by means of manurial experiments. Plots of about $\frac{1}{2}$-acre are divided into smaller plots, and upon these the varieties are raised under different systems of manuring. Some of the plots of every kind are manured with phosphates, and perhaps potash, others are not. Some of each are grown without nitrogenous manure, others with increasing quantities of nitrogen applied in the manure. It has been found that the mean results of a kind under the different manurings apparently offer the most reliable figures as to comparative value we can obtain in small-scale experiments.

The experience of the past few years has shown that the above method gives reliable results. For the sugar-industry of British Guiana the first essential to a sugar-cane is vegetative vigour. The system of cultivation which entails relatively prolonged ratooning demands it. The variety must be capable of being ratooned to third or fourth ratoons. Thus stress has to be laid upon field characters, such as vigour, weight of cane, number of canes per stool, and ratooning capacity, whilst the saccharine strength, but not the purity of the juice, becomes a less important consideration. It has been found that the small, rich sugar-canes, which at times give large yields as plant-canes have proved practically useless when ratooned. The canes gradually get smaller and smaller and the yields of sugar fall off. Our chief efforts are therefore directed towards obtaining large canes of good vigour, especially as it has been found in recent years that not only does the juice of a vigorous variety sometimes improve in saccharine content with continued cultivation when its vigour has become somewhat lessened, but that the selection of rich seedlings from vigorous parents promises to give very satisfactory results. For instance in the case of D. 625 and of the more promising varieties obtained from its seed the results were in 1911 and during the period 1909-1911:—

	Saccharose, lb. per gallon of juice.	
	1911.	1909-1911.
D. 625	1·735	1·696
D. 419	1·913	1·937
118	1·855	1·873
167	1·854	1·719
333	1·833	1·840
44	1·765	1·704
420	1·709	1·767
405	1·662	1·730
76	1·659	
335	1·577	

The juices of six of the seedling varieties are distinctly richer in saccharose than is the juice of the parent D. 625, whilst three are of the same or of lower strength.

VARIETIES SELECTED FOR BREEDING WORK.

Of late years the general selection and breeding work has been done mainly with D. 625, Bourbon, White Transparent and Red Ribbon. Coloured drawings and photographs, the actual size of the canes, have been made of the better of the seedlings. These paintings and photographs were exhibited at the Conference.

D. 625 seedlings. When classified by their prevalent colour the more promising seedlings from D. 625 fall into five groups :—

		Per cent. of varieties.
A.	Yellow canes :—	
	1. Pure yellow, whole coloured	18
	2. Yellow-green, some pure, some blotched with red	20
	3. Yellow or yellow-green blotched with red or reddish purple	37
B.	Red or reddish cane, whole coloured	12
C.	Purple or purplish red	8
D.	Yellowish-brown (D. 118)	1
E.	Dull greenish-yellow with some brownish blotches and with white incrustations (D. 419)	4

The colour characteristics of of the seedlings of D. 625 are the transition from pure yellow to yellowish green, and heavy blotchings with red to reddish purple, through red to purple or purplish canes. The pure yellow canes having blotching with red as their characteristic greatly predominate.

The general morphological characteristics of these seedlings are, in many of them, great length of the internodes with correspondingly large girths. The more typical examples are :—

	Internodes.	
	Length, cm.	Girth, cm.
No. 68	18·5	13·0
„ 73	17·5	13·0
„ 118	17·0	15·0
„ 167	16·5	15·0
„ 419	16·0	15·5

Others are stout canes similar in relative proportion to D. 625. The following are examples of them :—

	Internodes.	
	Length, cm.	Girth, cm.
No. 63	12·5	15·0
„ 75	11·6	15·5
„ 93	11·0	14·0
„ 108	9·0	15·5
„ 123	9·0	13·0
„ 326	10·0	14·5
„ 418	10·0	15·0

The eye-buds of the majority of the seedlings resemble those of the parent variety in being small, broad and flat with a more or less pointed apex. Very few of them show any indication of channels in the internodes. The internodes of the more promising varieties are cylindrical like those of D. 625, but in a fair proportion of the seedlings they are concave.

Bourbon. The seedlings from the Bourbon fall into four colour-groups as under :—

	Per cent. of varieties.
A. Yellow to yellowish-green	7
B. Yellowish-green and with red blotches ...	51
C. Yellow to reddish-green with red to purple blotches	21
D. Waxy-looking greenish to purplish-tinged canes	21

There is in them a very well-marked predominance of yellow to yellow-green types, whilst bright red to brownish-red blotches are common on many of them where they are exposed to the sun.

The majority of them are closely allied to the typical Bourbon in their morphological appearances, including the broad, somewhat flat and pointed eye-bud. Some varieties have more or less well-developed channels in their internodes, but the majority of them are not channelled. Their average size is 9 to 10 cm. in length and 12 to 13 cm. in girth. The internode of the typical Bourbon as grown in British Guiana varies from 9 to 12 cm. in length and from 12·5 to 15 cm. in girth. Some seedling varieties of the Bourbon, such as the following, tend to be abnormal in size :—

	Internodes.	
	Length, cm.	Girth, cm.
No. 101.	10·5	15·0
„ 217	11·5	15·0
„ 651	10·0	17·5
„ 721	13·0	16·0

The internodes of the above varieties are usually more or less tumid and are liable to longitudinal cracking.

White Transparent The seedlings of the White Transparent fall into five colour-groups thus:—

A. Yellow, tinged with red
B. Yellow, tinged and blotched heavily with red
C. Purplish, frequently with white bloom
D. Waxy-looking green with heavy white bloom
E. Striped or Ribbon canes

As a rule their internodes are long but not very stout, for instance:—

	Internodes.	
	Length, cm.	Girth, cm.
No. 90	16·0	13·0
„ 174	14·0	13·5
„ 189	12·0	13·0
„ 426	15·0	13·5
„ 454	13·0	13·5
757	15·0	12·0
„ 758	12·5	12·5
„ 1108	12·5	13·0
„ 1119	12·5	12·0

Their internodes are not infrequently somewhat concave, they usually have a more or less well-defined channel and the eye-buds are rounded with a pointed prominent apex.

Some of the varieties show a well-marked tendency to sport to striped canes, some of which closely resemble the Red Ribbon cane, whilst others, such as 98, are purple-red canes with dark-green stripes. A common characteristic of the varieties raised from White Transparent parentage is the tendency of many of them to a striping on their topmost joints, i.e., those covered by the living leaf-sheath, allied to that characteristic of the Red Ribbon.

Red Ribbon. The seedlings from the Red Ribbon are distinguished by the very wide range of variation shown by them. Practically all of them are self-coloured canes but some in certain seasons show faint signs of striping. They range in colour from bright-yellow to the darkest purple. As a rule the internodes are

relatively short and stout. A few of them, such as D. 124, are of very great size. The following are characteristic kinds :—

	Internodes.	
	Length, cm.	Girth, cm.
No. 4	9·0	14·5
„ 58	8·0	15·5
„ 145	10·0	14·0
„ 504	9·0	14·0
„ 511	11·0	16·0
„ 515	10·5	16·0

The internodes as a rule are smooth and without channels, thus differing from their parent Red Ribbon cane which always has distinct well-marked channels. The eye-buds as a rule are allied in type to those of the parent variety.

The second generation of seedling varieties from the Red Ribbon not unfrequently shows, after vegetative reproduction for some years, a reversion to a marked extent to its striped colour characteristics, whilst D. 145, at times, throws sports practically indistinguishable from its parent cane.

The following generalizations can be made of certain of the economic characteristics of the progeny of the parent varieties :—

D. 625—vigorous seedlings, juice generally richer than that of the parent, flower and seed sparsely, ratoon well, and resist drought.

Bourbon—proportion of selected seedlings low, the seedlings suffer very badly in drought, liable to fungoid disease, ratoon only moderately, some flower and seed freely, others but sparsely.

White Transparent—seedlings generally rich in juice, grow well as plants but are poor as ratoons and rapidly deteriorate, flower and seed very freely.

Red Ribbon—juice generally rich, flower sparsely as a rule. Good drought resisters.

These generalizations are based upon our lengthy experience with large numbers of seedling varieties. Our accumulated evidence as to the several economic characters of the different seedling varieties remains to be analysed.

MUTATION IN THE SUGAR-CANE.

Our experience in the search for new varieties of sugar-cane of high value by means of seminal reproduction—a search we have systematically carried on for over twenty-three years—has impressed on us the paramount importance to our objects of mutation, chance variation, or 'sporting' among the seedling progeny we

obtain. As we have shown it is not at present feasible to apply even if at all, the principles of Mendelism in a practical manner to the controlled hybridization of the, sugar-cane, and we believe that the experience of other West Indian workers in the field is practically in accordance with ours. Without the guidance of these principles we fear that there are few more chances of obtaining valuable results with canes of controlled hybridization parentage than with canes from parentage selected but not under absolute control. But it is feasible, although the amount of work required is enormous, to obtain from time to time by mutation varieties of great potential value, and our experience has proved to us that such chances are greater with the seeds of carefully selected varieties than with those of chance parentage and of numerous kinds. It is worthy of note that Java 100, B. 147, B. 208, D. 1135, D. 74, D. 95, D. 145, D. 625 and D. 1451 and nearly every cane that has hitherto proved to be of high value in various parts of the sugar world has been the result of mutation.

Where mutation has produced a cane of high vegetative vigour, it has proved feasible in the course of a few years to obtain from it by further mutation and selection, vigorous canes of satisfactory and even of high sugar content.

It was decided in 1903 to use in addition to the Java and Drumm methods of cross-fertilization, selections from the seedlings obtained from very vigorous varieties of those having a higher sugar content than the parent. This has been done with D. 625, and the investigation has been pursued with success. We have succeeded in raising from it seedling varieties of considerable vigour and of higer sugar content than the parent cane has attained to. Prominent among these new varieties are D. 419, D. 118, D. 167 and D. 1333.

In our present state of knowledge (or rather of lack of or incomplete knowledge) of the origin of the various kinds of sugar-cane whether of the older sorts or of the later 'mutation' varieties, we are forced to rely on mutation to obtain varieties of potential value for hybridization work. We have in fact to resort to mutation, followed by selection both cultural and chemical, as the preliminary to future hybridization.

As far as our experience has extended no reliance can be placed on obtaining by vegetative mutation 'sports' or new varieties of higher value than the one from which they have been derived. Many of these sports are deficient in vigour and are short-lived. The great majority of them can only be regarded as being colour mutations from the kinds from which they originated.

TRIALS OF NEW VARIETIES OF SUGAR-CANE AT THE EXPERIMENTAL FIELDS.

In the earlier part of this paper dealing with the action of nitrogenous manures on the sugar-cane is a table showing the effects of sulphate of ammonia in various proportions on a large number of varieties. The following table gives the records of twenty varieties under trial at the Experimental Fields during the crops of 1908 to 1911 as compared with the yields of the Bourbon, D. 625 and D. 145 given as standard kinds :—

Variety.	Parent.	Canes per acre, tons.	Expressed juice.			
			Per cent. of cane.	Specific gravity, $\frac{60^\circ}{17{\cdot}5^\circ}$	Saccharose, pounds per gallon.	Saccharose, tons per acre.
Bourbon ...	...	14·4	68·8	1·075	1·749	1·6
D. 625	Dyer	31·4	67·0	1·0722	1·696	3·3
D. 145	Red Ribbon	22·2	67·4	1·080	1·885	2·6
D. 419	D. 625	31·0	66·6	1·082	1 937	3·7
D. 118	D. 625	31·7	66·2	1 0798	1·873	3·6
D. 216	Bourbon	29·3	69·7	1·0769	1·751	3·4
D. 420	D. 625	25·1	65·2	1·0767	1·767	2·7
D. 281	Bourbon	22·8	68·8	1·0780	1·804	2·6
D. 504	D. 145	23·4	69 0	1·0744	1·715	2·6
D. 642	Bourbon	24·6	66·6	1·0719	1·696	2·6
D. 167	D. 625	23·1	66·3	1·0746	1·719	2·5
D. 44	D. 625	22·9	65·4	1·0757	1·704	2·4
D. 4399 ..	Bourbon	24 0	65·1	1·0754	1·670	2·4
D. 294	Bourbon	20·7	68·2	1·0757	1·790	2·3
D. 177	White Transparent	20·7	62·9	1·0787	1·820	2·2
D. 357	D. 115	20·0	68·2	1·0764	1·754	2·2
D. 398	D. 95	21·7	63·7	1·0733	1 723	2·2
D. 405	D. 625	21·8	61·9	1·0733	1·730	2·2
D. 4397 ..	Bourbon	22·2	69·4	1·0683	1·542	2·1
D. 433	D. 1087	21·4	61·2	1·0763	1·744	2·1
D. 4395 ...	Bourbon	20·5	68·9	1·0725	1·639	1·8
D. 638	Bourbon	16·8	64·0	1·0768	1·825	1·4
D. 4407	Bourbon	14·1	66·0	1·0736	1·649	1·4

The meteorological conditions during the three years have not been conducive to the production of heavy crops of sugar-cane on clay land such as that of the Experimental Fields. But the new varieties 419, 118, and 420, the progeny of D. 625, and 216 and 281, seedlings from the Bourbon cane, appear to be of much promise.

Some new canes of considerable promise have been tried as plant canes, and the following Bourbon seedlings, Nos. 651 and 721, appear to be promising varieties.

As practical men, planters will be directly interested in the relative returns during 1910 and 1911 of the more satisfactory varieties, under what may be considered as the normal nitrogenous manuring in British Guiana—300 lb. of sulphate of ammonia per acre :—

Variety.	Tons of cane per acre.	Tons of saccharose in expressed juice, per acre.
D. 118	33·6	4·1
D. 419	36·8	4·0
D. 642	34·9	3·7
D. 625	33·3	3·6
D. 167	29·0	3 4
D. 216	30·1	3·4
D. 281	26·3	3·0
D. 398	26·8	2·8
D. 145	21·9	2·7
D. 420	27·1	2·6
D. 504	23·1	2·5
D. 338	27·5	2·4
D. 433	25·2	2·3
Bourbon ..	18·9	2·2
D. 294	20·0	2·1
D. 405	21·4	2·1

An important point which appears to us to be not infrequently overlooked is the proportion of canes, cane tops and leaves in the produce of the variety when harvested. We pointed out earlier in this paper that the drain on the soil occasioned by the cultivation of the sugar-cane is largely that caused by the cane tops and the leaves which are reaped at crop time. These proportions are not recorded on, or are not obtainable from, plantations where varieties of sugar-cane are cultivated on the large scale. As determined at the Experimental Fields from the varieties now under cultivation, they are as follows :—

	Stalks or canes.	Cane tops.	Leaves.
Bourbon (1902-1912) ...	73·9	15·4	10·7
D. 625 „ ...	84·0	10·0	6·0
D. 145 „ ...	76·8	14·8	8·4
D. 419	81·1	12·4	6·5
D. 118	81·8	11·4	6·8
D. 216	86·2	7·5	6·3
D. 420	85·9	9·4	4·7
D. 281	81·5	11·3	7·2
D. 504	85·5	6·5	8·0
D. 642	85·0	7·5	7·5
D. 167	77·5	12·5	10·0
D. 44	77·2	11·8	11·0
D. 4399	81·1	10·8	11·0
D. 294	85·4	8·6	6·0
D. 177	76·4	13·3	10·3
D. 357	85·2	9·4	5·4
D. 398	83·6	8·0	8·4
D. 405	81·9	11·0	7·1
D. 439	81·4	10·6	8·0
D. 433	86·0	7·0	7·0
D. 4395	87·8	6·1	6·1
D. 638	75·7	13·6	10·7
D. 4407	82·2	9·3	8·5

Similar records were kept for many years of the proportions of the produce in certain varieties of canes which are no longer under cultivation at the Experimental Fields, but which have been under cultivation on sugar plantations in the Colony during the past eleven years. These are :—

	Stalks or canes.	Cane tops.	Leaves.
B. 208	83·1	10·8	6·1
D. 109	83·2	10·0	6·8
B. 147	79·4	11·1	9·5
White Transparent	79·9	12·5	7·6
D. 3956	81·2	11·7	7·1
Sealy	80·4	11·8	7·8
D. 74	86·6	7·8	7·6
D. 116	83·8	8·3	7·9
D. 95	78·5	11·5	10·0
D. 78	63·9	20·4	15·7

Determinations were made, in years in which the growth of the varieties appeared to be normal, of the amounts of dry fallen leaves or 'trash' from certain of the then more important varieties as compared with the amounts reaped of their produce. They resulted as follows :—

	'Trash' per cent. on the produce reaped.
Bourbon	17·0*
D. 625	12·9
D. 145	11·0
D. 109	15·5
D. 3956	18·9
D. 116	16·9
D. 95	19·5
D. 74	25·8
D. 78	18·3

*Note.—The proportion of 'trash' yielded by the Bourbon in its present condition is higher—22 per cent.

CHANGES IN THE PROPORTIONS OF THE VARIOUS PARTS OF THE PRODUCE REAPED.

During eight years prior to 1896, when the Bourbon gave very satisfactory results, the relative proportions of its produce were found to be :—

Stalks or canes.	Cane tops.	Leaves.
85·7	8·1	6·2

whilst for the past eleven years they have been

Stalks or canes.	Cane tops.	Leaves.
73·9	15·4	10·7

The proportion of canes to the produce reaped is nearly 12 per cent. less than it used to be when the Bourbon was in its full vigour.

In connexion with this point the gradual falling off in the percentage of canes in the produce harvested in the case of D. 78 may be of interest :—

	Canes, per cent. of produce.
1900 and 1901	81·5
1902	71·2
1903	70·3
1904	60·0
1905	57·6

The mean proportion of canes in the produce reaped from D. 78 as plants and ratoons during the first four years, 1894-1898, of its cultivation was 80·4 per cent. As is shown in the above, the proportion commenced to fall off in 1902 and quickly dwindled to 57·6 per cent.

The variety was replanted in 1904 but produced practically only tops and leaves with very little cane ; and at this stage we ceased to cultivate D. 78 in the Experimental Fields.

During the first four years of its cultivation the proportion of canes in the produce yielded by D. 145 as plants and ratoons was 81·9 per cent. Its average proportion during later years has fallen to 76·8—a decrease of 5·1 per cent.

As would be expected, the relative proportions of the produce are influenced to some extent by the manurial treatment of the plants. For instance, the Bourbon and D. 145 during the years 1902 to 1912 gave the following results :—

	Stalks or canes.	Cane tops.	Leaves.
Bourbon, no manure	72·3	13·6	14·1
„ stable-manure ...	68·9	17·8	13·3
„ nitrogenous manure	74·3	15·8	9·9
D. 145, no manure	73·8	13·9	12·3
„ stable-manure	68 4	19·1	10·5
„ nitrogenous manure ...	77·6	15·0	7·4

From the above we obtain the following as the mean proportion of canes per cent. of the produce reaped :—

No manure	73·0
Stable-manure	68·7
Nitrogenous manure	76·0

The canes grown on our heavy clay land when manured with large quantities of stable-manure are usually characterized by an objectionably high proportion of the whitish immature joints in their upper parts and tops.

Large numbers of seedling varieties are passing through the various stages of selection-trials at the Experimental Fields, but no advantage would be gained by detailing the results here.

THE PREVALENCE OF FUNGOID DISEASE AMONG THE VARIETIES IN 1911.

The prevalence of fungoid diseases—chiefly of rind fungus (*Colletotrichum falcatum* type)—among certain of the varieties under trial in 1911 was marked. Its distribution among the kinds is shown grouped under their parentages in the following :—

Percentage of total number of canes diseased.

Bourbon.		Meligeli.		Red Ribbon.	
Bourbon	26·1	D. 625 (plants)	2·3	D. 504	6 5
D. 4399 (plants)	11·0	„ (1st ratoons)	7·0	145	5·7
4399 (ratoons)	13·1	„ (old „)	10·0	58	0·3
4407	10·2	167 (plants)	2 2	White Transparent	
338	9·5	„ (ratoons)	6·8	D. 357	7·1
281	7·8	420	4·7	398	4·4
216	7·3	335	4·6	426	3·0
294	6·9	405	2·8	454	0·3
4395	4·4	118 (plants)	0·8		
4397	3·5	„ (ratoons)	2·6		
624	3·0	76	2·3		
305	2·7	44	2·3		
721	2·5	419	2·0		
317	2·2	333	1·4		
490	2·1				
638	2·0				
293	1·2				
604	0·6				

The more noticeable points are that the susceptibility of the Bourbon cane to fungoid attacks is far in excess of that of any other variety now under cultivation on the Experimental Fields; that its seedling varieties D. 4399 and D. 4407 are also subject to a marked extent to these attacks, and that whilst D. 625 as plant-canes and 1st ratoons is fairly resistant, as older ratoons it is almost as susceptible as are the two above-mentioned varieties of Bourbon seedlings.

The new varieties of promise—D. 119 and D. 419—appear to be resistant to the attacks of fungi.

AREAS OCCUPIED BY VARIETIES OF SUGAR-CANE IN BRITISH GUIANA AND THE RESULTS OF THEIR CULTIVATION.

Since 1901 the sugar plantations in British Guiana have furnished annually to the Board of Agriculture returns showing the areas on them under cultivation with various varieties of sugar-cane and the results of the reaping of their produce.

The following table shows the areas which were planted with the more important varieties for the crops of 1902, 1906, 1910, 1911 and 1912. It illustrates the gradual supersession of the Bourbon by other varieties, the rapid rise into favour of B. 208 and D. 625, the slow but steady increase in favour of D. 145, the extraordinary rise and fall in area of D.109, the rise and fall of B. 147 and of the Sealy variety, and the very marked decline in estimation of the White Transparent, of D. 78, D. 95 and D. 74. Pratically it affords a guide to the general but varying opinions of the British Guiana sugar planters as to the merits of the varieties of canes which they cultivate on the large scale.

ACRES OCCUPIED BY VARIETIES FROM THE YEAR 1902 TO THE YEAR 1912.

	1902.	1906.	1910.	1911.	1912.
Bourbon	66,048	50,910	28,823	24,252	22,403
White Transparent ...	1,927	1,439	357	251	203
D. 109	1,727	8,386	4,063	3,261	2,548
D. 78	629	179	14	5	...
B. 147	599	1,733	1,096	754	657
D. 145	442	1,842	4,299	4,382	4,618
D. 95	335	170	69	21	14
D. 74	216	118	29	47	47
D. 625	79	3,357	16,650	21,672	23,699
D. 115	72	49	42	59	76
B. 208	43	2,125	9,636	9,531	8,812
Purple Transparent ...	49	...	...	...	...
B. 109	41	112	73	42	59
Sealy	40	220	188	28	36
D. 116	36	79	146	105	111
D. 117	9	88	37	37	30
Green Transparent ...	5	98	584	495	593
Diamond 185	...	55	487	703	808
D. 3956	...	28	56	56	50
B. 376	...	...	188	194	176
D. 4399	...	...	113	140	148
D. 4397	...	...	48	55	58
Diamond 399	...	...	...	82	13
Diamond 382	...	...	...	21	22
D. 118	...	...	...	2	24
D. 199	...	...	...	70	26

Large areas are occupied on the various sugar estates by trials of numerous new varieties obtained from Barbados or Java, or, in the majority of cases, raised locally. But few of these have occupied total areas of more than 25 acres at any one time. Hence they have not been included in the above table.

A wide area on various estates is under cultivation with mixed varieties of sugar-cane, whilst in many places the Bourbon cultivation is largely intermixed with D. 625 and other well-known kinds.

YIELDS OF VARIETIES PER ACRE.

The yields of commercial sugar per acre have been reported to the Board of Agriculture of British Guiana during each year since 1901, from almost all the sugar plantations in British Guiana which have had varieties in addition to the Bourbon under cultivation. The following table shows the number of years in which results with each variety have been reported, the mean yields in tons of commercial sugar (96°) per acre reported during these periods, the number of years in which a variety has given a mean yield in excess of that of the Bourbon, the maximum and the minimum returns of each variety, and the years in which they were recorded :—

Variety.	Number of years cultivated.	Mean yields in tons of sugar per acre.	Number of years in which yield exceeds that of Bourbon.	Maximum yields.		Minimum yields.	
				Tons.	Years.	Tons.	Years.
Bourbon	11	1·72	—	2·18	1901	1·53	1907
D. 625	11	2·11	11	2·95	1901	1·72	1907
D. 145	11	1·90	10	2·17	1901	1·72	1907
B. 208	7	1·89	7	2·18	1905	1·72	1907
D. 109	11	1·74	5	2·14	1902	1·45	1911
B. 147	11	1·73	6	1·99	1901	1·40	1907
White Transparent	11	1·48	1	2·03	1901	1·26	1904
B. 376	4	1·71	3	2·17	1908	1·43	1909
Green Transparent	6	1·90	6	2·07	1909	1·71	1910
D. 3956	3	1·57	2	1·78	1908	1·33	1910
B. 109	8	1·61	4	1·88	1905	1·43	1909
Diamond 185 ...	3	2·62	3	3·15*	1908	2·03†	1911
Sealy	10	1·78	6	2·49	1901	1·43	1911
D. 74	10	1·80	5	2·23*	1910	1·33	1907
D. 116	5	1·69	4	2·00	1909	1·43	1908
D. 95	11	1·73	7	2·24	1904	1·37	1906
D. 117	7	1·21	2	1·76	1904	1·21	1908
D. 78	11	1·27	2	1·89	1901	0·50*	1911

* One plantation only.
† Two plantations only.

For the purposes of this paper the relative yields of the varieties as compared with the British Guiana standard kind—the Bourbon—are of more general interest than are the reported yields per acre, although the latter are of course paramount to the proprietors and managers of plantations. To enable such comparisons to be readily made the following table has been drawn up in which the mean yields reported

from every one of the plantations during each year of the records are shown, calculated to their relationship with the yields of the Bourbon taken as 100; and the mean yields, similarly worked out, of each of the varieties to the Bourbon during the periods over which they have each been cultivated are given:

Cane.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.	1911.	Mean.
Bourbon	100	100	100	100	100	100	100	100	100	100	100	100
D. 625	135·3	143·2	143·0	118·3	136·5	108·8	112·4	114·7	112·0	112·5	110·2	122·4±3·0
D. 145	99·8	123·3	101·1	106·1	119·2	117·0	112·4	107·3	115·0	111·2	112·1	110·0±1·5
B. 208	...	...	...	...	131·3	107·6	112·4	106·2	118·6	113·1	110·9	114·3±2·1
D. 109	87·6	121·6	112·3	114·6	108·1	99·4	101·9	88·1	90·0	99·4	92·3	101·4±2·5
B. 147	91·3	110·8	106·5	91·4	110·0	97·6	91·5	104·0	94·6	100·6	112·7	101·0±1·9
White Transparent	93·1	105·7	88·1	76·8	87·5	76·0	91·5	77·9	95·2	97·5	87·0	88·7±2·1
B. 376	...	...	...	...	...	...	...	122·6	86·1	101·2	102·5	103·1±4·7
Green Transparent	...	...	...	...	...	106·4	119·6	115·2	124·7	106·9	122·9	116·0±2·9
B. 3956	...	..	...	...	...	...	...	100·6	...	83·1	102·5	95·4±4·7
D. 109	...	...	...	106·1	110·5	92·9	119·6	90·0	86·1	92·5	102·5	100·0±3·8
Sealy	114·2	118·2	98·9	98·1	106·2	81·9	103·2	106·2	..	106·9	91·1	102·6±2·2
D. 74	93·1	115·9	80·6	86·6	111·2	91·5	86·9	...	129·5	134·4	115·3	104·3±4·7
D. 116	...	...	...	...	...	...	109·1	80·8	120·4	107·5	103·1	104·2±4·1
D. 95	102·3	117·0	105·3	104·2	134·6	78·0	76·4	82·0	110·2	103·1	91·0	100·4±3·6
D. 117	...	...	...	107·3	93·8	68·9	103·2	68·3	82·5	70·0	...	84·4±4·4
D. 78	86·7	104·0	87·6	70·0	100·6	82·5	70·0	65·5	57·8	42·5	31·8	72·6±4·8

From the probable errors of the mean yields, the possible errors of the annual returns of the varieties have been calculated. The theoretical possible error in excess of an annual return of D. 625 is 17·1 per cent. of the yield of the Bourbon for that year, or, say, ·28 ton of sugar per acre. The records fall within this limit except for the years 1902 and 1903, which must be therefcre regarded as abnormal. For D. 145 the possible error is 8·5 per cent. (·11 ton of sugar per acre), and with the exception of 1901 its records are reliable in comparison with that of the Bourbon. For B. 208 the theoretical possible error of a single year's records is 12 per cent. (·20 ton of sugar per acre) in excess and, except for the year 1905, its records may be regarded as normal. The calculated possible error for D. 109 is 14·2 per cent., equal to ·23 ton of sugar per acre. in excess or deficit, and except for that of 1902 its records are reliable. For B. 147 the possible error in excess or deficit is 10·8 per cent. (·18 ton of sugar per acre), and all its results fall within this limit. The possible error of each of the years in the White Transparent records is 12 per cent. (·20 ton of sugar per acre) and, with the exception of 1902, all fall within this. The Green Transparent results indicate a possible error of 16·5 per cent. in excess (equal to ·28 ton of sugar per acre), and all its records are within this.

The weighted or corrected means of the records of these important varieties, each of which has been cultivated on a very large scale and on numerous plantations for several years, are included in the following table, which may be accepted as showing the true relationship of the various varieties to the Bourbon and to one another, on the plantations of British Guiana during the period 1901 to 1911 :—

Variety.	Tons of sugar.	Bourbon taken as 100.
Bourbon	1·72	100
D. 625	2·01	117·4 ± 2·4
D. 145	1·92	112.2 ± 1·1
B. 208	1·91	111·5 ± 1·3
D. 109	1·70	99·4 ± 2·2
B. 147	1·73	101·0 ± 1·9
White Transparent	1·49	87·0 ± 1·7
Green Transparent	1·99	116·0 ± 2·9

There is a tendency for the increase in yields caused by the substitution of varieties other than Bourbon for the Bourbon during the earlier years of their introduction into general cultivation to be exaggerated. The falling off in yield normal to the practice of long ratooning must be taken into consideration. During the first four or five years after the introduction of a variety a far larger proportion of it is under cultivation as plant canes than there will be of the standard variety to which it has to be compared. Hence we consider that the value of the varieties relative to the Bourbon will be more accurately ascertained if we eliminate from the calculation the results of the first four years' records of each variety. We thus get the following, which may

be regarded as closely approximating to their values relative to the Bourbon when grown on soils suitable to them :—

Variety.	Years.	Tons of sugar per acre.	Bourbon taken as 100.
Bourbon	7	1·64	100
D. 625	7	1·93	117·4 ± 2·6
Green Transparent	3	1·94	118·2 ± 4·4
B. 208	4	1·89	115·2 ± 2·3
D. 145	7	1·85	113·0 ± 1·1
D. 74	7	1·83	111·4 ± 5·7
B. 147	7	1·77	107·6 ± 2·8
Sealy	7	1·63	99·2 ± 3·2
D. 109	7	1·59	97·0 ± 2·0
B. 109	4	1·52	92·8 ± 1·5
D. 95	7	1·58	96·5 ± 6·2
White Transparent	7	1·34	87·5 ± 2·1
D. 117	4	1·33	81.0 ± 5·8
D. 78	7	1·06	64·4 ± 6·0

The weighted mean results for the whole period, and the mean results for the limited number of years enable us to state with confidence that the varieties D. 625, D. 145 and B. 208 may safely be expected to give, on the average of the results of their cultivation on the large scale in any normal year in British Guiana, returns in excess of those of the Bourbon to at least the following extent :—

D. 625 ... ... 15 per cent.
D. 145 ... ... 11·5 „ „
B. 208 ... ... 12 „ „

On soils in Berbice, where practically all its records have been obtained, the Green Transparent—a cane which appears to us to be practically, if not actually, identical with the Selangore cane—can be similarly relied upon to give yields 13·5 per cent. in excess of those of the Bourbon.

On the other hand, in the case of widespread plantings of B. 147, average excess yields of more than 3 per cent. over that of the Bourbon cannot reasonably be expected ; whilst similar

plantings of D. 109 and White Transparent may be anticipated to result in average yields possibly 4 per cent. and 15 per cent. respectively less than that of the standard.

To discuss the relative growths of the various varieties in the different sugar-growing districts of the Colony would lengthen out this paper to an inordinate extent, and would add to it details that are of interest only to the proprietors and managers of individual plantations. It has been abundantly proved that a variety which gives excellent returns in one district or on one plantation in the Colony may fail more or less completely in other districts or on another plantation. Similarly on plantations having a variety of soils it has been proved that whilst one kind of cane will give highly satisfactory results on one class of the soils it fails on others, or in place of failing it may grow with such very marked vegetative vigour as to render it economically useless as a sugar producer. Knowledge of which varieties suit the district and which suit the various soils of a sugar plantation are only obtained by large scale trials in the districts, and on its various soils, and this knowledge is possessed, or is eagerly sought after, by the great majority of the managers of the sugar cane plantations of British Guiana.

In the trials of sugar-cane varieties reported from the various experimental stations, well-marked differences in the saccharine contents and the quotients of purity of the juices of the various varieties are invariably noticeable. But when the factory-results with varieties are recorded at several plantations, and over some years, the differences in their saccharine strength are not observable to anything approaching the same extent But the characteristic relative differences in the quotients of purity and of non-sugars appear to be fairly constant, and mark the variety under diverse conditions of climate, soil and cultivation. The following illustrates the differences in saccharine content between the juice of sugar-canes of a variety grown at the Experimental Fields and crushed in our small mills, and of the same variety grown on sugar plantations and crushed in their factories :—

Variety.	Saccharose in lb. per gallon of expressed juice.	
	Experimental Fields.	Sugar plantations.
B. 208	2·091	1·587
D. 95	1·959	[illegible]
D. 145	1·930	1·460
Sealy	1·841	1·455
D. 116	1·764	1·443
Bourbon	1·780	1·435
White Transparent	1·943	1·432
B. 147	1·698	1·408
D. 109	1·939	1·407
D. 625	1·685	1·407

SOME DEFECTS OF NEW VARIETIES.

During the earlier years of the trials complaints were very numerous as to the difficulties, apparently inherent, in crushing canes of the new varieties in the mills. These difficulties have been largely overcome, in some factories, by the installation of crushers of various types for breaking up the canes prior to passing through the rollers of the mills, and in others by passing canes of several varieties, mixed together, through the mills at the same time.

Complaints were also very common as to difficulties with the megass of many of the new varieties in its use as fuel. These difficulties have in the cases of some varieties which have lost their exuberant vegetative vigour to some extent, lessened, but the fact still remains that the megass obtained from many of them is not so suitable for fuel as was that of the Bourbon cane during its best days.

GENERAL CONCLUSIONS.

The results which we have considered and our general experience point to the importance of recognizing that certain varieties are suitable to certain localities and to certain kinds of soil. For instance, we have the Purple Transparent, the White Transparent, the Red Ribbon, D. 74, D.95 and D. 1135—canes which are very suitable for cultivation in the northern parts of the northern tropics, and in the southern parts of the southern tropics, and which may do well in light and well-drained soils in the more central parts of the tropics; we have in British Guiana D. 625 suitable for moderately heavy to heavy soils, but which on rich, light soils assumes so active a vegetative vigour that its period of maturity becomes unduly prolonged, and it must on them be regarded as unsuitable for the production of sugar; D. 145 which prefers moderately heavy but friable land: and B. 208 which flourishes on friable and light to moderately heavy friable lands, but which is an absolute failure on heavy stiff clays. Even the Bourbon cane in its palmiest days did not flourish on either very light or very heavy land as it did on the moderately heavy but friable lands of many of our plantations. As on our plantations the nature of the soils varies considerably in passing from the front lands to the back lands, it is evident that a plantation to give consistently satisfactory returns must be planted with several varieties, each on its appropriate soil.

There are indications, although perhaps not very well-marked as yet, that a policy of rotation of varieties suitable to the plantation and to its soils may be advantageous.

We are satisfied that in every variety of sugar-cane there exists a tendency towards running out, although in certain cases there may not be any evidence of it for very many years; and to meet this eventuality it is advisable and even necessary for sugar plantations to have nurseries on a fairly large scale in which several to many of the newer varieties which show promise may be cultivated.

As an important aid in the combat against the running out of varieties, whether due to senility, to insect and fungoid attacks to long-continued cultivation on the same soil, or to the effects of oft-repeated droughts, the establishment of nurseries on a still large scale, whence supplies of selected tops of the best quality and of reliable purity of strain can be obtained for planting or for replanting varieties in the cane fields of the sugar plantations, appears to be highly advisable.

We have barely touched in this paper on the suitability or adaptability of the varieties of sugar-cane to factory treatment. That is a most important subject, but one that can only be usefully dealt with by practical planters, engineers and technical sugar chemists of long experience in the working of varieties of sugar-cane in the factories with which they are connected.

[Pages 95 to 218, issued March 31, 1913.]

RUBBER EXPERIMENTS IN TRINIDAD AND TOBAGO.

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RUBBER AND FORESTRY.

Introduction of Rubber Plants.

The earliest records available of the introduction of rubber plants into this Colony date from the year 1876. In this year two *Hevea brasiliensis* plants were received from Kew and planted in the Botanic Gardens. The records of 1880 refer to them as being over 20 feet high. These two plants were in all probability grown from the seeds introduced by Wickham from the Tapajos district in 1875; they may possibly date from the earlier expedition of Collins in 1874. Of these two trees we have been able to trace one, which is in good health and yielded 5,230 seeds for this year's crop.

In 1878, *Hevea guyanensis* was introduced, and in 1880, one *Hevea pauciflora* plant, three *Castilloa elastica*, and twenty-four Landolphia plants.

There is a small *Hevea pauciflora* tree, about 30 to 35 feet high, growing in the paddock at the back of the nursery in Government House Grounds. This may be the one imported in 1880, as its range of growth is stated to be 40 to 45 feet. There are two large Hevea trees over 80 feet high, situated in the Emperor Valley; these are estimated to be over thirty years of age,

and can hardly be the *H. guyanensis* referred to above, as the quality of rubber yielded is excellent, the latex flows readily and the yield is comparatively high. The returns for a period of six months, July 1 to December 31, 1911, were, respectively, 11 ℔. 5 oz. and 10 ℔. 3 oz.

Hevea confusa, Hemsley. There is no definite record as to the date when this type of Hevea was introduced, but in 1898 Mr. Hart reports: 'A tree of *H. confusa*, Hemsley, formerly known as *H. Sprucei*, also bore fruit. The distinguishing characters of the seed are its large size, its angular form, and the softness of its outer covering when compared with those of *H. brasiliensis*.'

In the following year (1899) he writes: 'Trees of *Hevea confusa* are bearing seeds, but these have not been largely sown as the rubber produced by this tree, so far, is found to be of inferior quality.'

In 1898, from 170 seeds of this rubber introduced by Dr. Bovallius, two plants were obtained; these have been planted at the Experiment Station, and are at present about 15 to 20 feet high.

In 1911, 200 Hevea plants from the Rio Negro district were planted at the rear of the Experiment Station. The leaves are small and sharp-pointed (lanceolate) and differ entirely from those of *H. brasiliensis*. They may possibly turn out to be *H. minor* or *H. rigidifolia*.

In 1911, two Hevea seeds were discovered in a consignment of Sapucaia nuts (*Lecythis Zabucajo*). These were planted and have grown into sturdy plants. They appear to be entirely different to others already in the Colony. About 150,000 Hevea trees are now under cultivation, by far the most of which are planted in Trinidad. So far, only a small number of Hevea trees have been planted in Tobago.

The first Castilloa plants, as has been seen already, were introduced in 1880, and at least one parent tree is still in existence. This, although tapped severely in the past and also badly damaged by forest fires—so much so that the trunk has been partly hollowed—yielded 5 ℔. of dry rubber in two tappings, in the space of one month, when tapped to the height of 40 feet.

Castilloa rubber was extensively boomed by the late Mr. J. H. Hart during the years 1888-97, and the cultivation has been rapidly taken up in various parts of Trinidad and almost exclusively in Tobago. The estimated number of trees under cultivation is: Trinidad 500,000; Tobago 120,000.

Funtumia elastica was first introduced in about 1895, under the name of *Kicksia africana*; in about 1899 the generic name was changed to Funtumia, and the difference in the two types, *F. elastica* and *F. africana*, clearly demonstrated. In 1902 visits were made by the Assistant Superintendent to examine the plantations for any evidence of *F. africana* having been by accident distributed, with negative results. Trees of both types are to be found at the Experiment Station, St. Clair, and are maintained so that the specific differences in the two types may

be pointed out on enquiry. About 25,000 to 30,000 trees are at present under cultivation in the Colony.

Landolphia sp. and *Ficus* sp. Landolphia plants were received in 1880, but, as far as is known, have not been cultivated to any extent. There are a few vines of *Landolphia Klainii* at the Experiment Station, and a small quantity of good rubber has been prepared from them.

A few *Ficus elastica* trees and also *Ficus Vogelii* have been planted in the Colony ; at present, for value, they can hardly be considered more than decorative plants. There is an avenue of *Ficus Vogelii* at Haleland Park, Maraval ; the trees have grown well and bleed freely. A sample of rubber prepared in March 1911 was doughy and not very elastic ; it yielded 34·4 per cent. of resins, on analysis.

Experimental Work on Hevea Rubber.

Experimental work for the last year has been conducted on twenty-five trees, two of which, situated in the Emperor Valley, are approximately thirty years old, and the remainder at the St. Clair Experiment Station, about thirteen years old. These trees are growing on extremely poor soil, in a district where the average annual rainfall is about 60 inches.

Some of these trees are more advanced and larger in girth than the rest, and it is possible that the smaller ones may be supplies put in to replace others. The trees at St. Clair were originally interplanted among Castilloa rubber, but soon outstripped them, and the Castilloa trees were accordingly cut down. Situated amongst these trees are some which bear distinctive features, and these have been denoted by asterisks in the returns given. Their salient differences are: bark, coppery or rust-coloured, instead of grey ; bark, thin and usually only slightly over $\frac{1}{4}$-inch in thickness, in some cases much less ; latex, creamy yellow ; rubber, slightly sticky and inferior in elasticity ; leaves, semi-transparent, with reticulated or criss-cross veins, especially noticeable when the sunlight is passing through the leaves ; seeds, larger than those of *H. brasiliensis*, round-angled, greyish blotched, and somewhat elastic or yielding when pressed. These seeds are fairly distinct from the seeds of the *H. confusa* tree : they somewhat resemble *H. pauciflora* in general aspect, but are larger. General characters of tree : tall, good growth, umbrageous, fairly dense foliage.

As there were two large trees at Government House Gardens, one yielding white latex and the other yellow latex, both identified at Kew as *Hevea brasiliensis*, it is possible that these may be offsprings from the seeds of the latter. Unfortunately, the yellow latex-yielding tree was cut down, some two or three years ago, and it is impossible to obtain any record of the nature of the bark, seeds, etc., for comparison. It has been suggested that they are hybrids between *H. brasiliensis* and *H. confusa*, but this can only be assumed for the present, since, as is stated by Huber (1911) : 'It is not proved that Hevea can hybridise, but it is not impossible.'

It would be interesting to isolate plants from these seeds, with a view of ascertaining whether the offspring is constant, or if any variation on Mendelian lines results.

Eight additional trees of a similar type which have lately been tapped on the full herring-bone system for half the girth of the tree yielded, during the months of November and December 1911, 45·4 oz. of dry rubber, being an average each of 5·7 oz., approximately.

The inferior trees have produced very little seed during the past two years, and all such seed has been collected and forwarded to the Laboratory, to avoid any possible admixture with good types

The policy of the new Department has been to plant seeds from authenticated trees, which have been proved to give good quality rubber and a large yield. Some 10,000 of these selected seeds have been planted out. The Confusa tree has been lopped of all its branches.

The rubber produced by *H. confusa* and *H. pauciflora* is of inferior quality ; the latter type hardly possesses any elasticity. Although they exhibit a certain amount of wound response, the yield is very disappointing ; it required ten tappings of *H. confusa* to obtain 2 oz. of dry rubber.

A trial shipment of this so-called inferior rubber at St. Clair was recently valued at 4*s.* 3*d.* per ℔., Fine Para being quoted at 4*s.* 6*d.* to 7*s.* 7*d.* (See Table I.)

The trees were tapped every other day on the following systems : (a) single and double herring-bone on half the girth of the tree ; (b) single herring-bone on opposite quarters (only on the two largest trees) ; (c) double herring-bone on quarter girth of tree ; (d) single herring bone on quarter girth of tree.

Of the above four systems, the last proved more favourable and was less injurious to the tree. The double herring-bone system, with either alternating or opposite lines, is apt to cause damage where the gauge meets the vertical line.

Besides the experiments conducted at the Experiment Station, 100 trees at Nonpareil estate, Sangre Grande, all over 18 inches in girth and ranging between three and a half to four and a half years were tapped by the Department, on behalf of the proprietor, Mr. E. A. Robinson. Tapping was continued for sixteen days (working every alternate day) on the Gallagher system of one single V at 1 foot from the ground. The weather was very rainy and accordingly most of the scrap was lost. The total yield for the sixteen tapping days was 3½ ℔., and the experiment had to be discontinued as the trees were seeding heavily, and it was feared that some of the crop might be lost. It would seem advisable not to tap until the tree is about 2 feet in girth, and to employ the single herring-bone system up to about 5 feet in height. The biscuits were prepared by coagulation with a dilute solution of sulphuric acid, as is described below, and at the International Rubber Exhibition were reported on as follows : 'Fine, well prepared, smoked Hevea biscuits in excellent condition.....these biscuits show little room for improvement.'

A sample of these biscuits, on analysis, gave the following percentage results: water 0·50, albuminoids 2·75, resins 5·05, caoutchouc 91·44, insoluble matter 0·26.

Numerous experiments with coagulating reagents were made involving the use of pyroligneous acid, wood smoke, acetic acid with and without creasote, and carbolic acid, phenol-sulphonic acid, salicylic acid, lime juice, etc. The creasoting of the latex previous to coagulation was not found to be of any advantage.

The latex was either coagulated instantaneously by using (a) 1 c.c. of 10 per cent. formic acid for every 100 c.c. of latex, or by adding 10 drops of 5-per cent. sulphuric acid and allowing the coagulum to cream and rise to the surface overnight, in enamelled plates.

Specimens of thin blocked sheets, prepared by immediate coagulation either by pyroligneous, acetic or sulphuric acids were reported on by the examiners appointed for the West Indian exhibits as follows: 'Good tough Hevea sheets, apparently excellent quality, some paler than others.'

The biscuits prepared by slow coagulation with sulphuric acid were stated to be: 'fine smoked Hevea buiscuits, good colour and thickness and in excellent condition..... ...about the best Hevea on the Stand.' For those made with lime juice, pyroligneous acid and sulphuric acid, without smoking, the report was: 'fair average quality unsmoked Hevea biscuits.'

The sheets prepared by quick coagulation, and blocked, are much tougher than ordinary biscuits; they however take a longer time to dry. A 5-per cent. sulphuric acid solution was found to be the cheapest and most efficient coagulant to use. Contrary to expectation and other expressed opinions, biscuits prepared over a year ago are in excellent quality and good preservation. Castilloa and Funtumia biscuits of equal dates have long since perished. The sulphuric acid solution used is fairly dilute; 5 per cent. and 1 c.c. of concentrated sulphuric acid will coagulate twenty times the amount of latex coagulable by 1 c.c. of ordinary commercial acetic acid; while the corresponding price of sulphuric acid is at least one half that of commercial acetic acid. The advantage of smoking the biscuits to dryness has been amply demonstrated.

Two hundred to 250 c.c. of latex was found to be a convenient amount to work upon; this amount was convenient for the ordinary enamelled iron soup plate. To every 100 c.c. of latex either 10 drops of a 5-per cent. solution of sulphuric acid or 10 drops of the juice of a fresh lime were added and the whole well stirred; the pans were then covered over to prevent dust and insects falling in, and left undisturbed. On the following morning the clotted biscuit was lifted out, gently washed in water and pressed; it was then rolled out with a wooden roller and allowed to dry for twenty-four hours; during this period, the biscuit gradually contracts, and the moisture may be seen exuding like perspiration from tiny pores—in ordinary terms, the biscuit sweats. After this the biscuits were smoked, till they assumed an amber colour, became transparent in appearance and had a characteristic smoky smell. The biscuits may be smoked immediately afer rolling, but owing to their dampness are

apt to gather particles of soot and other foreign matter. Smoking usually occupies from three to five days. It does not seem advisable to smoke air-dried biscuits or to continue smoking the biscuits after they have once become transparent — in either case they get soft and flabby and often sticky in parts. In working on latex which had been preserved with formalin and afterwards coagulated with formic, acetic, or sulphuric acids it was found that the dry rubber produced was nearly always almost colourless, a slighty higher amount of acid being required to produce coagulation. Samples of Hevea blocks and biscuits prepared on the above lines have recently been valued by an expert attached to a large rubber manufacturing establishment, as being equal to fine Ceylon plantation rubber quoted at 6*d.* per ℔. higher than the ruling prices for fine Para native.

In regard to Para seeds, in connexion with the so-called floating test for distinguishing unsound seeds, it will be interesting to note that experiments conducted with fresh seeds, obtained locally, gave a specific gravity ranging from 850 to 920 (pure water, 1,000). The seeds were placed in strong alcohol and water added gradually, stirring the meanwhile; and the density at which the seeds remained poised in the liquid, neither floating nor sinking, being taken as the specific gravity. These seeds were subsequently planted and the gravities of those which germinated recorded. As all the seeds are lighter than water, this test is of no value for Hevea and other very oily seeds.

In the two older trees the percentage of rubber in the latices obtained in February and March 1911, on the second day of tapping, was 69·5, eventually declining to 27 per cent. when tapping ceased. This decrease occurred while the plants were shedding their leaves and preparing for new growth, reaching its maximum when new leaves, etc. were appearing.

The following were the results obtained:—

Hevea sp. at the Botanic Gardens, on the upper road to the Valley.

Age about 30 years.	No 12.	No. 13.
Diameter at 1 foot from ground ...	54 inches	64½ inches.
Diameter at 6 feet from ground ...	44 „	51 „

Trees were tapped on two opposite quarters, with five cuts on the half herring-bone system.

Daily yield of Latex (in cubic centimetres).

	February.							
	13	15	17	19	21	23	25	27
Rainfall ...	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.
Tree No. 12 ...	Scrap	60	60	95	190	230	180	200
„ „ 13 ...	only	120	335	380	405	417	450	410
...		180	395	475	595	647	630	610

	March.						
	1	3	5	7	9	11	13
Rainfall ...	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.
Tree No. 12 ...	180	200	175	210	150	170	200
„ „ 13 ...	380	330	305	205	85	50	35
	560	530	480	415	235	220	235

Both trees dropped their leaves at the end of February. New growth started about March 9.

Daily yield of Rubber (dry) in grammes.

Tree No.	February.							
	13	15	17	19	21	23	25	27
12 and 13 ...	22·4	125·1	227·0	243·6	348·8	308·3	292·4	256·2
Percentage rubber in latex	...	69·5	57·3	51·3	59·0	47·6	46·4	42·0

Trees No.	March.							
	1	3	5	7	9	11	13	
12 and 13 ...	223·0	212·9	162·9	136·5	72·5	59·9	...	= 2,671·59 or 95·20 oz. 5·95 lb.
Percentage rubber in latex	39·8	40·0	33·9	32·9	30·8	27·2	...	

The steady decrease in the percentage of dry rubber contained in latex from the end of February, while the trees were preparing for new growth, is very noticeable.

The percentage of resins in the dry rubber from these two trees was found to be 2·32.

BROKER'S REPORT ON SAMPLES OF HEVEA BISCUITS, FROM EXPERIMENT STATION, ST. CLAIR.

6, Mincing Lane,
London, 11 December 1911.

Gentlemen,

We have examined the following goods, imported by you and beg to hand you our report upon the quality, and value of the same, viz:—

Per Salybia to Trinidad
One Case India Rubber

L & P No.	Case		Worth about per pound.
1.	1	26 lb. Small smoked biscuits well prepared and in good condition, but mostly rather resinous and a little weak in quantity	s. d. 4 9
2.	1 bag	1 lb. 8 oz. Small smoked biscuits few good, mostly stuck together and rather resinous in quantity	4 5
3.	1 bag	3 lb. 5 oz. Smoked brown scrap, part clean, part slighty heated and barky in quantity	3 9

One case two bags

We are, Gentlemen,
Yours faithfully,

Sgd. LEWIS & PEAT.

Auctions, 12 December 1911.
Inscription of rubbers (A.E.C.).

Lot No. 1. Consisted of 26 lb. of smoked biscuits from the 13-year-old trees (good yielders) at St. Clair Experiment Station. The resin content is not high as might be conceived from the broker's report—but the rubber had been recently smoked, and there was not sufficient available space to air them properly afterwards. If they had been exposed for a longer period, the apparent resinous nature, due to a slight film of empyreumatic matter would have disappeared.

Lot No. 2. Consisted of 1½ lb. of smoked biscuits from poor-yielding trees No. 4-8 and 29-36. Their quoted value is four pence less than the preceding samples.

Lot No. 3. Scrap, blocked after smoking.

The prices quoted at auction on December 12, were as follows: —

	s.	d.
Best blocked Ceylon Plantation (Lanadron)	5	1
Ordinary „ „ „ biscuit	4	8½
Fine hard Para	4/6-4	7½

HEVEA SPECIES. MONTHLY YIELD OF RUBBER.

Experimental Station, St. Clair. *Emperor Valley (Botanic Gardens).*

Tree No.	Age, years.	Girth 3 feet from ground, 1911.	Yield of dry Rubber, 1911.										Remarks. N.B. Trees all tapped to about 5 feet high.
			August 1910. March 1911.		July 1911.	August 1911.	September 1911.	October 1911.	November 1911.	December 1911.	Total for 6 months.		
			lb.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	lb.	oz.	
1	13	28¼	3	6·5	9·97	13·09	12·60	12·78	11·68	7·40	4	7·40	
2	„	36¼	3	5·86	6·33	13·66	11·17	12·20	11·31	10·00	4	0·70	
3	„	34	3	5·80	11·05	10·02	7·42	7·80	6·15	7·94	3	1·09	
4	„	31¾	0	14·33	1·69	1·81	1·05	1·12	3·62	1·00	0	8·24	Nos. 1-11 tapped on full herring-bone system half girth of tree.
5*	„	33¾	0	8·03	0·44	0·63	0·70	1·04	0·74	1·34	0	4 86	
6	„	34¾	1	6·7	4·82	2·91	3·60	3·02	1·14	4·40	1	3·90	
7*	„	35			3·77	3·08	2·75	2·84	2·11	2·10	1	0·68	
8*	„	36½			5·53	4·57	4·18	3·92	3·01	3·40	1	8·60	

HEVEA SPECIES MONTHLY YIELD OF RUBBER.—(*Continued*).

Experimental Station St. Clair. *Emperor Valley (Botanic Gardens).*

Tree No.	Age, years.	Girth 3 feet from ground, 1911.	Yield of dry Rubber, 1911.										Remarks. N.B. Trees all tapped to about 5 feet high
			August 1910. March 1911.		July 1911.	August 1911.	September 1911.	October 1911.	November 1911.	December 1911.	Total for 6 months.		
			lb	oz.	oz	oz.	oz.	oz.	oz.	oz.	lb.	oz.	
10*	13	...	...	...	...	...	...	1·52	...	1·20	...	...	
11*	„							2·78		1·80			
12	30	54	3 (Six Weeks tapping only.)		34·47	32·79	27·75	31·40	28·50	26·90	11	4·90	Two half herring-bone on opposite quarters
13	30	64	3 (Six Weeks tapping only.)		28·82	32·35	25·25	19·34	33·52	34·30	10	3·30	Two half herring-bone on opposite quarters
14	13	21¾	Not tapped till July 1911.		7·56	3·80	2·94	2·79	3·11	1·43	1	5·63	
15	„	25½			14·41	12·57	9·00	8·42	7·96	6·70	3	11·1	
16	„	24½			5·08	3·27	3·32	2·80	3·55	4·04	1	6·04	14-19 half herring-bone on
17	„	27½			5·16	5·15	4·61	5·13	4·60	3·12	1	11·72	¼ girth of tree.

Experimental Station St. Clair. *Emperor Valley (Botanic Gardens).*

Tree No.	Age, years.	Girth 3 feet from ground, 1911.	Yield of dry Rubber, 1911.									Remarks.
			August 1910. March 1911.		July 1911.	August 1911.	September 1911.	October 1911.	November 1911.	December 1911.	Total for 6 months.	
			lb.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	lb. oz.	N.B. Trees all tapped to about 5 feet high.
18	13	29¾	Not tapped till July 1911.		21·14	14·91	14·98	14·92	1·700	13·43	6 4·63	
19	,,	29¼			7·48	6·26	4·80	5·14	0·51	4·60	2 0·70	
20	,,	28⅛			6·04	3·99	3·56	3·27	2·91	3·06	1 6·67	20-25, full herring-bone on ¼ girth of tree.
21	,,	23			2·84	21·53	2·10	2·84	1·96	2·22	0 14·52	
22	,,	29			10·02	8·53	6·62	7·20	6·77	4·20	2 11·13	
23	,,	20¾			6·95	4·05	4·72	3·45	3·93	3·40	1 10·5	
24	,,	23			6·76	4·72	4·79	3·94	5·11	4·60	1 13·9	
25	,,	27⅛			6·70	5·87	5·02	4·98	4·20	3·70	1 14·1	

* These trees have not come true to the parent *Hevea brasilensis*. They are of good growth, umbrageous and with rust-coloured bark.
With the exception of 12 and 13, these trees are planted 24 feet apart.
Nos. 12 and 13 are situated over 50 yards apart.

Further experimental tapping with Elastica trees has been undertaken at Verdant Vale estate and at Lure estate, Tobago.

The Tobago results are recorded in the table below.

Some trees, measured and tapped at Verdant Vale, gave the following results :—

Tree No.	Approximate age.	Girth, Nov. 2, 1910,	Girth, July 1911,	Increase in 8 months,
		inches.	inches.	inches.
H ...	8 years	43	48	5
J ...	12 „	72	76	4
K ...	10 „	48	50	2
L ...	8 „	39	42	3
M ...	8 „	35	38	3
		Average increase		3·4 inches.

Latex yield.

Tree No.	Nov. 2, 1910, c.c.	Nov. 17, 1910, c.c.	July 1911, c.c.
H	560	430	56*
J	750	430	1,020
K	250	160	510
L	100	35	113
M	100	70	170

*Tree cankered through some previous tapping.

The rubber has been prepared by the method detailed in the Annual Report of this Department for 1910-11. The Trinidad and Tobago rubbers prepared by this method, and forwarded to the International Exhibition, were sold in November 1911 and fetched 3*s.* 4*d.* per ℔.—the highest price obtained for Castilloa rubber.

Experiments were conducted to ascertain the possibility of roughly determining the percentage of rubber in the latex by the use of a hydrometer, without any definite results.

The specific gravity of latex A was 1·0033 and plus twice its bulk of water 1·005,

The specific gravity of latex B was 1·005 and plus twice its bulk of water, 1·010.

Samples sent from the Cabeceras estate (Verdant Vale) Arima, were sent to a large rubber manufacturing firm in Manchester, who very kindly examined them. An abridged copy of their report is quoted :—

Manchester,
21 December 1911.

There were four samples of rubber marked A, B, C, and D.

A. Unsmoked sheeted Castilloa rubber from Poole Syndicate, Trinidad. Trees about 10 years old.

B. Lightly smoked sheeted Castilloa from Verdant Vale (Cabeceras), Trinidad. Trees about 10 years old.

C. Extra smoked sheeted (rubber) Castilloa from Pembroke, Tobago (Lure estate).

Medium smoked sheeted Castilloa from Pembroke, Tobago (Lure Estate, A. E. C.).

I enclose a sheet giving full particulars of our trials with these rubbers, and also comparisons of our similar results from the various rubbers which we use.....you will see reference to what we call 'resin loss'. This means that each of these rubbers is submitted to certain tests which are given by the British Government and many of our leading railways to guide the mauufacturer as to the class of rubber he may use for his contracts. They give off so much loss in resin from themselves and as the Government maximum loss of resin for rubbers which we may use for their work is 10 per cent., you will see that in every case this is higher. We also give you the same tests for genuine Para rubber, Peruvian ball rubber, and for what is known here as 'Ceylon Medium Biscuits'. In each of these you will see the resin loss is below the Government requirements, and if we had to use this rubber for these contracts, we would require to mix it in proportion with one or other of these three, so as to keep within their 10 per cent. loss.

The vulcanized india-rubber is to be of a homogeneous character throughout, as evidenced by microscopical examination ; is to be thoroughly compressed, free from air-holes, pores, and all other imperfections ; is not to contain any crumb rubber, recovered rubber, or other treated or waste rubber substitutes of any kind, and is to stand the tests mentioned below without its quality being impaired.

The quality of the caoutchouc used for all vulcanized india-rubber goods described in this schedule must be of such a character, that after it has been made up into the vulcanized and finished article as defined above, not more than 10 parts per cent. of organic matter and sulphur, calculated on the non-mineral matter present, can be extracted from the rubber by boiling it for six hours in a finely ground condition with a 6-per cent. solution of alcholic caustic potash.

The above is the Government test for resins allowed in rubbers, as mentioned in our letter.

RESIN LOSS UNDER GOVERNMENT TEST.

A ...	... 12·84	B ..	. . 16·35
C ...	... 12·65	D ...	... 13·40

RESIN LOSS OF FOLLOWING RUBBERS UNDER ABOVE TEST.

Para	1·50 per cent., never more than 2.
Peruvian Ball ...	8·5 per cent.
Ceylon Medium Biscuits	5 per cent.

LOSS AFTER WASHING AND DRYING HIS RUBBERS.

A ...	... 5 per cent.	B ...	... 10 per cent.
C ...	... 5 „ „	D ...	... 5 „ „

LOSS AFTER WASHING AND DRYING THE FOLLOWING.

Para	... 18 per cent.
Peruvian Ball ...	... 22·5 „ „
Ceylon Medium Biscuits	Nil.

VALUES.

Para to-day	price 4/3 plus 18% loss	5/2
Peruvian Ball	„ 3/9 22% „	4/10
Ceylon Medium Biscuits	„ 4/6 Nil.	

We value all his rubbers, A, B, C, D, at 4*s.* plus, of course. whatever loss they show after washing and drying, and this is in our opinion their fair relative value, compared with the three rubbers, Para, Peruvian Ball, and Ceylon Biscuit on their to-day's prices as given.

RESULTS OF TAPPING CASTILLOA. LURE ESTATE, TOBAGO.

1st. Tapping from April 6-May 18. 1911. (Trees fruiting.)

Tapping day.	No. of trees tapped.	Total yield of dry rubber,		Average yield per tree,	Remarks.
		lb.	oz.	oz.	
1	2	1	0	8·0	From 1st to 19th day trees were tapped to height of 20 feet on half girth of tree.
2	6	3	12	10·0	
3	11	3	9	5·0	
4	12	6	7·5	8·6	
5	12	4	0·5	5·3	
6	9	2	2	4·0	Scrap = 1 lb. 1 oz.
7	9	0	14	1·5	5-year saplings.
8	6	2	12	7·3	
9	10	6	12·5	10·8	
10	13	4	14	6·0	
11	12	4	5·5	5·8	
12	15	4	5·5	4·6	
13	17	4	1·5	3·8	
14	12	3	1·75	4·1	
15	16	3	2	3·1	
16	14	2	14	3·3	
17	22	3	10	2·6	
18	7	3	10	8·3	
19	13	2	10	3·5	
20*	12	4	6·5	5·8	
21*	12	4	11·5	6·3	
22*	12	4	14	6·5	
23*	12	2	12	3·7	
24*	7	2	4	5·1	
25*	9	2	10	4·6	
26*	6	2	9	6·8	
	288	92	2·75	5·12	

* Trees tapped to 20 feet height but all round trunk.

2nd Tapping from August 7-September 15, 1911.

Tapping day.	No. of tree tapped.	Total yield of dry rubber,		Average yield per tree,	Remarks.
		lb.	oz.	oz.	
1	9	2	12	4·9	
2	10	3	8	5·6	
3	8	3	12	7·5	
4	9	3	14	6·9	
5	9	2	4	4·9	From 1st to 17th day trees were tapped to height of 20 feet on half girth of tree.
6	6	3	4·5	8·7	
7	10	3	8·5	5·6	
8	12	3	2·5	4·2	
9	12	0	12	1·0	
10	13	3	4·5	4·4	
11	12	1	4·5	1·7	
12	15		14	0·9	
13	12	2	2·5	2·9	
14	10	1	10·5	2·6	
15	13	0	10·5	0·8	
16	12	1	10·5	2·2	
17	12	1	0	1·3	
18*	12	1	14	2·5	
19*	12	1	12	2·3	
20*	12	1	6	1·7	
21*	8	0	10	1·2	
22*	10	0	10·5	1·05	
23*	12	0	10	0·8	
24*	5	0	10·5	2·1	
Total scrap		6	8·5		
	254	53	7·5	3·37	

* Trees tapped all round to height of 20 feet.

Tapping operations were only conducted for three hours per day, as the labourers lived some distance from the estate. The total cost of collecting and curing the rubber, on this account, was somewhat high—working out at 39c. (1s. 7*d*. per lb.) The trees were manured with sodium nitrate three days before the second tapping was commenced.

RUBBER EXPERIMENTS IN BRITISH GUIANA.

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PART I. EXPERIMENT STATION TRIALS.

At the seventh West Indian Agricultural Conference an account of the progress of rubber experiments in the Colony of British Guiana to the end of the year 1907 was given by one of us, and was published in the *West Indian Bulletin*, Vol. IX, pp. 254-7.

During the four years 1908-12 much attention has been given in the colony to the planting of rubber, and the experiments with various kinds of rubber-producing trees have been extended.

Experiments at Botanic Gardens, Georgetown.

At the Botanic Gardens, Georgetown, experiments in the growing of *Hevea brasiliensis* were laid out in the shelter belt, in the friable soils of the nursery, in the very heavy soils in the Brickdam Field, and on the eastern side of the Rice Experimental Field, where the conditions closely resemble those of the abandoned sugar-cane fields of the coastal region of the colony. The growth in all these situations has been far from satisfactory, but that of those trees in the rice-field, well-sheltered from wind by a belt of secondary growth of forest trees has been more vigorous than in the more exposed situations. The effect of wind upon Para rubber trees has been clearly demonstrated, and it has been ascertained that the constant sea-breezes that sweep throughout the year across the coastal lands of the colony retard their growth to a most marked degree. Spells of dry weather, which usually occur in this part of the colony at least twice a year, have resulted in 'wintering' of the trees, and this has further tended to retard their growth.

From these experiments it has been demonstrated that the heavy clay-soils of the coastal region, formerly cultivated in the sugar-cane are not suited for the successful cultivation of Para rubber, and our numerous observations on the trials carried on by the sugar estates on such lands fully confirm the conclusions drawn from the above experiments.

HEVEA BRASILIENSIS at Onderneeming Experiment Station.
Age 4½ Years.

SAPIUMS at Plantation Rubberton, North Western District.

Trials have also been made at this Station with the two common rubber-producing Sapiums of the Colony (viz: *Sapium Jenmani* and *S. cladogyne*), and also with *Castilloa elastica*, *Funtumia elastica*, *Manihot Glaziovii*, *Manihot Ramanso* and several other rubber-producing plants. These trials have all shown that none of the plants submitted to experiment are suitable for planting on these heavy, wind-swept lands.

Various systems of tapping have been undertaken on some of the young Sapiums growing in the nursery of the Botanic Gardens. The cuts, where carefully made, have healed satisfactorily, but if the cuts were made too deep, open gaping wounds resulted that took a long time to close up. The yields obtained from these trees were not very good, and the rubber had to be collected almost entirely as scrap.

Experiments at Onderneeming Experiment Station.

The experiments with rubber plants at Onderneeming Experiment Station, situated near the mouth of the Essequibo River, have been considerably extended. Para rubber, *Sapium Jenmani*, *S. cladogyne*, *Castilloa elastica* and *Funtumia elastica* have been experimented with. The growth of the Para rubber has been generally satisfactory, and over 20 acres are now planted, mainly as an intercrop with coffee. *Sapium Jenmani* has done fairly satisfactorily on some soils, while *Castilloa elastica* has generally made unfavourable growth. *Funtumia elastica* is healthy and the majority of the plants are making fair growth. There are over 200 trees of *Funtumia elastica* at this Station and some of them have been tapped. The yields were poor but the product obtained was of excellent quality.

Tapping of five of the larger Para rubber trees was commenced in December 1910 and continued, weather permitting, until December 1911, with the exception of the months of April, May and June 1911 when the trees were flowering. The particulars of the trees selected for experiment were as follows:—

	Age.	Girth at 3 feet from ground.	Method of tapping.
1.	8 years ...	29 inches	$\frac{1}{2}$ herring-bone $\frac{1}{4}$ girth
2.	7 „	23 „	„ „ „
3.	5 „	21 „	„ „ „
4.	7 „	19$\frac{1}{2}$ „	basal $\frac{1}{2}$ V.
5.	6 „	19 „	„

Tapping was carried out every alternate morning and the total number of re-openings made during the whole period was 147. The latex from all five trees was coagulated together with

dilute acetic acid; coagulation was complete in six hours, and the rubber was washed with cold water, rolled out and then dried. A total of 4 lb. 2 oz. biscuit rubber was obtained during the tapping period, of which not less than four-fifths came from trees 1,2, and 3.

Some of the rubber prepared was exhibited at the Second International Rubber Exhibition held in London in June and July 1911, and was reported upon by Messrs. Lewis and Peat as follows :—

'Five small Para biscuits from first tappings at Onderneeming Experiment Station. Good quality and well-prepared.'

The trees that have been tapped continue to make satisfactory progress and several more trees have reached a size at which they can be tapped.

Experiments at Christianburg, Demerara River.

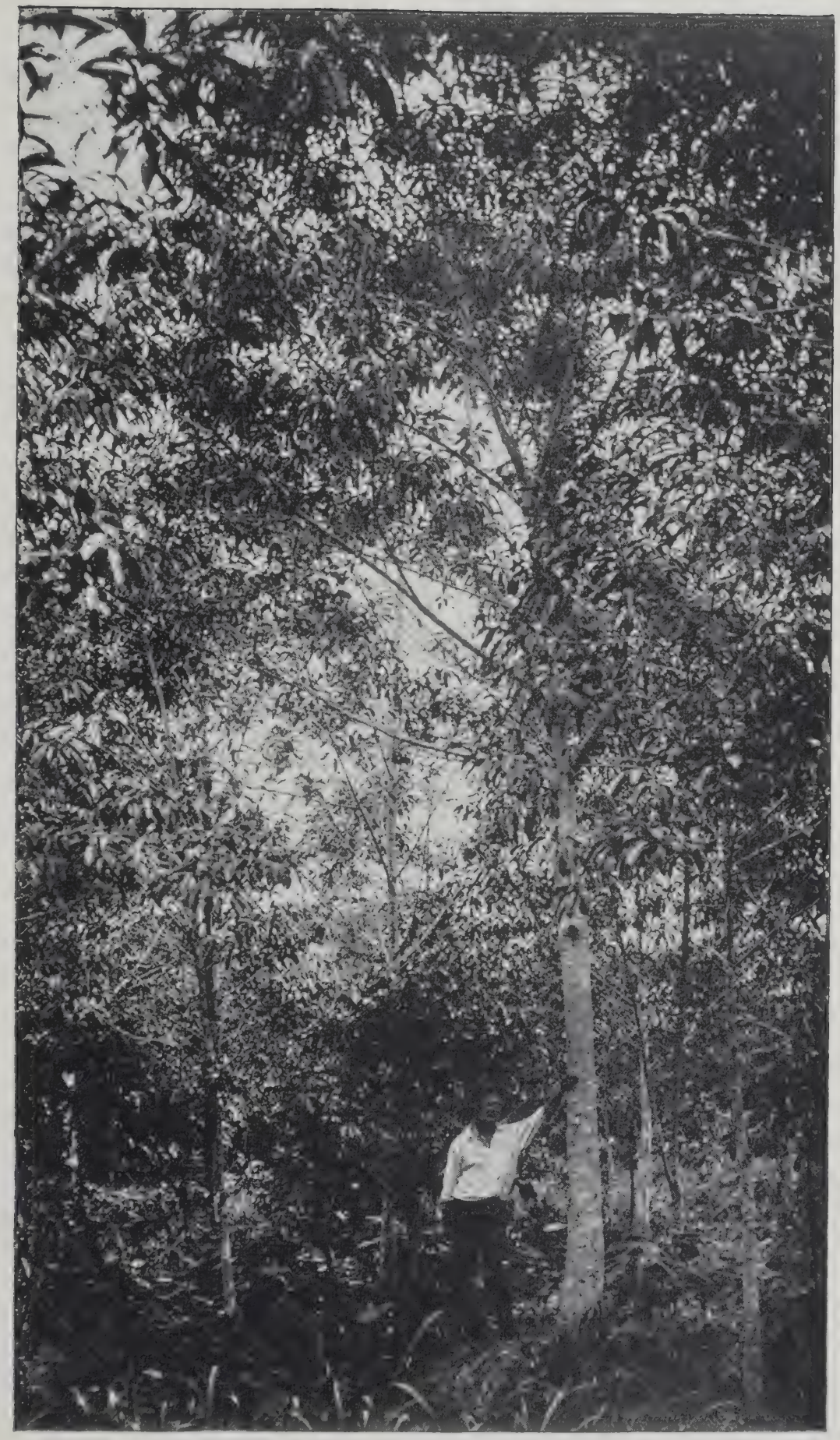
The trials at this Station were started in order to test the suitability of the soils of that place, which are representative of the soils of a great area of the upper parts of the Demerara River district for rubber cultivation. Two small areas of less than an acre each were planted in 1906, one of nearly 15 acres was planted in 1908 and 1909, and one of 5 acres in 1910 and 1911.

The plantings of 1906 consisted of plants of *Hevea brasiliensis* and *H. confusa*, *Manihot Glaziovii*, *Funtumia elastica*, *Sapium Jenmani*, and *S. cladogyne*. *Hevea brasiliensis* made favourable early growth, whilst *Sapium Jenmani* and *S. cladogyne* appeared to be somewhat promising. The plantings of 1908 and 1909 therefore consisted mainly of *H. brasiliensis*, with a further experimental area of the Sapiums. A few *Manihot Ramanso* were also tried. The soil at this Station varies from a somewhat heavy but friable clay to a soil of a light sandy nature. The heavier types of soil are found at the lower levels, and in some places the clays are quite stiff. The lighter soils are overlying masses and beds of coarse gravel of bauxitic laterite.

The early growth of Para rubber both on the heavier and on the lighter soils was satisfactory, but on the lighter sandy soils the rate of growth has steadily fallen off. Experiments with leguminous cover crops (Bengal beans, *Lucaena glauca*, woolly pyrol and pigeon peas) are in contemplation, as also are manurings with potassic and phosphatic manures.

The growth of the Sapiums on the light soil has been very unsatisfactory and their culture will be discontinued except on the heavier types of soils.

In 1910 and 1911 an extension of slightly over 5 acres was planted with Para rubber on the compact alluvial clay-land of the river bank. This soil is totally different in physical and chemical properties from other soils experimented on, but it is typical of a large area of land in this and other districts. The drainage of this land has received careful attention and the young plants are making very satisfactory growth. This soil



Sapiums cultivated in North-Western District, British Guiana.

also appears to be suited to the growth of *Sapium Jenmani*, as the few trees growing on it have made promising growth.

Experiments at Issorora Station, Aruka River.

North Western District.

This Experiment Station in the North Western District was commenced in 1907, and planting was begun in 1907 and 1908. The experiments were devided under two heads:(1) the examination of various kinds of rubber-producing trees under varying conditions of planting and cultivation to ascertain which were the most suited for cultivation in that part of the colony, and (2) the critical examinations of the conditions necessary for the most successful growth of the indigenous rubber-producing trees (*Sapium Jenmani* and *S. cladogyne*), and of the Para rubber tree (*Hevea brasiliensis*).

Several kinds of rubber-producing trees have been experimented with under the following conditions :—

(1) On the flat the land consists of a mixture of clay and pegass, and before being empoldered was covered with a typical river swamp-forest.

A. *Hevea brasiliensis* and *Sapium* spp. planted in the forest without any clearing or drainage.

B. *Hevea brasiliensis*, *Sapium* spp. and *Funtumia elastica* planted in the forest which had been cleared of the smaller under-bush and some of the larger trees. to allow access of top light. This section was drained.

C. *Hevea brasiliensis*, *Sapium* spp. and *Funtumia elastica* planted in 3-rood lines cleared through the forest with drains on either side of them : 3-rood belts of forest trees were left between the several clearings.

D. *Hevea brasiliensis*, *Sapium* and spp., *Castilloa elastica* planted in well-drained, empoldered and thoroughly cleared land, the weeds being kept down by the temporary growth of provision crops as catch crops.

2. On the hill slopes, where the land consists of a reddish laterite, a gravelly ferruginous clay derived from an epidiorite. Beds of *Hevea brasilensis*, *Funtumia elastica*, *Castilloa elastica* have been planted in 3-rood lines through the forest.

The results of these experiments have been as follows : –

SECTION A.

Practically every Sapium plant died out in Section A, and although re-supplies were put in periodically, no plants were alive after two and a half years. Only the Hevea that were growing in spaces where they could obtain a fair amount of light grew at all ; a very large number died, while many made little or no growth. Hence the number of supplies required here was very large. After two and a half years a very thorough inspection was made of this section, and it was clear that planting rubber in the forest without any attempts at

clearance or drainage was economically impracticable. It was therefore decided to cut down the forest of Section A, and clear, burn, and plant it up on plantation lines with Para rubber. The preparatory clearing of the land was done in 1911, and planting will be carried out as soon as suitable weather allows.

SECTION B.

The Funtumias in this section died out within two years from date of planting, the majority dying during the second year after planting out. A large number of the Sapium died, while the others made but little progress. Some of the Para rubber trees grew fairly satisfactorily, especially when they were situated in open spaces and obtained sufficient light; but where the over-head shade from the forest trees was dense, their growth was practically *nil*. The majority of the Heveas in this section were of a delicate nature: even where they grew at all satisfactorily, the girth measurements of the stems were small, and the leaves were thin and of delicate texture. After two and a half years, it was obvious that the planting of Para rubber under the conditions prevailing in this section could not be economically practicable, and therefore the remaining large trees were cut down and the section cleared for planting up on recognized rubber-plantation lines.

SECTION C.

Funtumia elastica failed entirely in this section and was replaced with *Hevea brasiliensis* in 1910. Some of the Heveas and Sapiums, especially in the centre rows where they obtain sufficient light, have grown satisfactorily, but in the rows nearest the belts of forest trees where they have been somewhat shad-d, they have not made satisfactory growth. The growth of the Heveas was better than that of the Sapiums. Their growth, however, was irregular, and after the first two years was unsatisfactory, especially as regards girth. Therefore it was decided that this section should have the belts of forest-growth cut down, and the whole planted up. It was demonstrated that trees planted in lines cut through the forest grew irregularly, and that they would take many years before their girth measurements were sufficiently large to allow tapping.

SECTION D.

The Funtumias in this section grew irregularly. They were planted 20 feet apart and therefore grew rather bushy. Pruning was carefully attended to and supplies put in immediately after any died out. In this manner a fairly satisfactory stand of Funtumia has been obtained. Their growth compares most unfavourably with that of either Hevea and Sapium, and hence none of the trees have yet reached a sufficient size for tapping to be commenced.

The *Sapium Jenmani* and *S. cladogyne* planted in this section have made vigorous growth. The low-lying pegassy-clay soil suits them well, and their girth measurements have always

been in excess of the girth measurements of the Para rubber trees. The pruning of these plants has needed constant attention. Except for an infestation of a few of the trees with *Saissetia nigra*, *Saissetia hemisphaerica*, they have been vigorous and healthy. These scales were kept in check by spraying with rosin compound, as it was fouud that their control by *Cephalosporium lecanii* was too slow a process to be relied upon except when the climatic conditions were distinctly favourable.

Measurements of the Sapium trees growing on this section have been taken at regular intervals since planting, and the following table showing the average girth measurements at 3 feet from the ground, taken in February 1912, may be of interest:

Measurements of Sapium trees, four years old.

	Section D.									
	Hill Foot Bed.	Bed No. 1	Bed No. 3.	Bed No. 5.	Bed No. 7.	Average.	Northern Side-line Parapet.	Façade Parapet.	Parapets around Sections A, B, C.	Mean average.
No. of trees	29	19	28.	37	42	155	28	11	94	288
Girth, inches.	$18\frac{1}{2}$	$17\frac{3}{4}$	21	21	$21\frac{3}{4}$	$20\frac{1}{2}$	16	13	$22\frac{1}{2}$	$20\frac{1}{2}$

In Section D, beds numbered 1, 3 and 5 were planted during the fortnight ended January 18, 1908, and bed 7 during the fortnight ended February 1, 1908.

The parapets were all treated in the same manner as Section D and were planted during the fortnight ended February 15, 1908. The measurements of all trees, whether those originally planted or supplies, have been included in these averages, and therefore the figures above represent the average girths of 288 trees of Sapium four years after planting. The largest tree measures 33 inches, and the average increase in girth during the year has been $3\frac{5}{6}$ inches.

The Para rubber in this section, with the exception of two low-lying beds difficult of drainage and planted in 1909-10 have grown satisfactorily. For the first two years of growth provision crops were taken off in addition to the rubber, in order to reduce the weeding costs. All trees were tapped at about 15 feet, except where they had branches naturally below that height. The growth has been vigorous and healthy, and with the exception of attacks by the larvae of *Dilophonota ello*, no pests have been observed. At least, two or three types of Para rubber trees, judging from the external appearance of the bark, occur in this section, and investigations

into these types will be undertaken when tapping experiments, which are now in contemplation,* are commenced.

Measurements of the Para rubber trees in this section have been kept at regular intervals and the following table gives the average girth measurements at 3 feet from the ground as recorded at the beginning of February 1912.

Measurements of Para rubber trees; 4 years old.

	Section D.										
	Hill Foot Bed.	Bed No. 1.	Bed No. 4.	Bed No. 6.	Bed No. 8.	Average.	Northern Side-line Parapet.	Southern Side-line Parapet.	Façade Parapet.	Parapets around Sections A, B, C.	Mean average.
No. of trees.	31	19	42	41	40	173	29	19	12	98	331
Girth, inches.	10	16	$13\frac{3}{4}$	$10\frac{1}{2}$	$10\frac{1}{2}$	$12\frac{1}{2}$	$12\frac{1}{2}$	$13\frac{7}{8}$	13	$11\frac{1}{2}$	$12\frac{1}{3}$

In Section D, beds 1, 4 and 6 were planted during the fortnight ended January 18, 1908, and bed 8 during the fortnight ended February 1, 1908. The parapets were all planted during the fortnight ended Feburary 15, 1908. All trees, whether originals or supplies, have been measured. There are seventy-seven trees with a girth measurement of 15 inches or over, and the average increase in girth during the year ended Feburary 1912 has been 4 inches. The largest Hevea measured $25\frac{1}{2}$ inches. The first general flowering of the Para rubber trees has taken place this year.

Hill-Slope Beds.

The Funtumias on the lateritic hill-slope beds have done better, on the whole, than those on the flat clayey lands. In most cases they grew very bushy and had to be frequently pruned. On one occasion they were affected by scale insects, but generally they have been healthy and free from pests. The Heveas have grown much more slowly on the hill slopes than on the flat lands, but some trees now seem to be making better headway. A large number of the Castilloa died out, and others were at times badly infested with the akee-fringed scale (*Asterolecanium pustulans*). Some, however, have recently been making better growth, and appear to be keeping healthy.

*Commenced June 1912.

INDIGENOUS SAPIUM JENMANI at the Rubber Reserve, Bonasika.

The following are the measurments of four-year-old rubber trees on the lateritic hill slopes :—

Measurements of Trees on Hill Beds, Four Years Old.

		Bed 1.	Bed 2.	Bed 3.	Bed 4.	Average.
Hevea.	No. of trees.	28	25	16	14	83
	Girth, inches.	$8\frac{1}{2}$	$7\frac{1}{2}$	$9\frac{1}{4}$	$6\frac{3}{4}$	8
Funtumia.	No. of trees.	16	16	13	4	49
	Girth, inches.	12	9	10	8	10
Castilloa.	No. of trees.	20	14	14	3	51
	Girth, inches.	12	10	$10\frac{3}{4}$	$14\frac{1}{2}$	$11\frac{1}{4}$

In 1909, an extension was made on the northern side of the central path leading up the slope of the hill. Fifteen 3-rood beds were planted up with various rubber-producing plants, but *Hevea brasiliensis* soon showed that it was the only kind that was of promise. All supplies put in were *Hevea brasiliensis*, and now these beds are planted with practically nothing else. The growth has been very slow, and only those trees which are in the centre rows fully exposed to the full light of the sun are of promise. A very large number of the plants put out have died, and the number of re-supplies has been high, but since the policy of encouraging a sod has been adopted, the deaths have been less numerous. It has also been found on these hill slopes (some of which are steep) more economical to brush over the beds monthly, and to encourage the growth of grasses than to clean-weed periodically every three or four months.

A further area of 30 acres of flat land was taken in and empoldered in 1910-11. Ten acres of this was planted with Para rubber in the same year, a further 10 acres in 1911-12 and the remaining 10 acres will be planted next year. It is also proposed that different varieties of coffee be interplanted in the rubber of the 10 acres to be put into cultivation in 1912-13, while a further 4 acres of selected hill-slope land is being planted with Para rubber, balata, and letter-wood (*Brosenium Aubletii*), interplanted with Arabian coffee and with leguminous cover crops.

Experiments at the Bonasika Reserve.

A reserve which contained a large number of indigenous Sapium rubber-producing trees (*Sapium Jennani* and *Sapium*

cladogyne) was set aside at Bonasika on the Essequibo River for the purpose of investigations into the value of these trees. Very careful trials were made with various methods of tapping and of coagulation of the latex. These were commenced in September 1908, but it was soon evident that the amount of latex and of cured rubber quickly fell, upon repeated tappings. The following were the mean results obtained with some of the trees over successive tapping periods :—

Tapping period.	Times tapped.	Dry rubber, oz. per tapping period.
	1st set.	
1. September 1908	3	3·25
2. October and November 1909	4	·97
3. March 1910	2	·87
4. August 1910	7	·24
5. October and November 1910	3	·30
	2nd set.	
1. October and November 1909	4	5·28
2. March 1910	1	1·32
3. October and November 1910	3	·90

A more complete series of trials was made in the autumn of 1910, using groups of trees of various girths and presumably different ages, with the following average results per tree :—

Tapping period.	No. of tappings.	Dry rubber. oz. per tapping period.
Trees over 50 inches in girth at 3 feet from ground :—		
Not previously tapped, August	7	3·43
Once previously tapped, November	6	1·02
Several times previously tapped, August	7	1·45
Several times previously tapped, November	5	·61
Trees between 30 and 40 inches in girth at 3 feet from ground :—		
Not previously tapped, August	9	1·70
Once previously tapped, November	8	1·14
Several times previously tapped, August	9	1·04
Several times previously tapped, November	7	·66
Trees under 30 inches in girth at 3 feet from ground : —		
Not previously tapped, August	5	·85
Once previously tapped, November	6	·53

During these series of tapping-trials the trees were tapped on alternate days. It was found that the yield of latex gradually lessened until it ceased to flow. The duration of the flow of

PARA RUBBER at Issorara Experimental Station.
Age $1\frac{1}{2}$ years.

latex varied with different trees from three to nine days. No explanation of this variation was obtainable, but as a general rule the trees between 30 and 50 inches in girth yielded latex for longer periods of tapping than did either those of a greater or of less girth.

At Bonasika in the trials from 1898 to 1911, the trees over 30 inches in girth at 3 feet from the ground produced an average yield of dry rubber per tree per tapping period which is shown in the following :—

No. of period.	Period.	Dry rubber, oz.
1	September 1908 ...	8·33
2	October 1909	5·16
3	March 1910	1·83
4	August 1910	1·93
5	November 1910	1·08

Thus it was found that during a period of two years the yield of dry rubber from mature Sapium trees was 18·33 oz. per tree. This yield cannot be considered as satisfactory. The majority of the experiments were carried out under the personal supervision of one of us, and therefore the yield obtained may be taken as a fair indication of what indigenous Sapium rubber trees, growing under conditions similar to those prevailing at Bonasika will supply when bled to a height of 6 to 7 feet from the ground. A certain amount of Sapium rubber is obtained in the Island District of the Amazon. This is obtained by cutting the trees down and bleeding them to dryness. The rubber is either shipped alone, or, more commonly, the latex is mixed with *Hevea brasiliensis* latex. The reason given for cutting the trees down on the Amazon is that they do not stand tapping with the machindero, for the wounds heal badly.

In our experiments at Bonasika, a further unfavourable feature gradually became noticeable during the repeated tapping periods. The rubber yielded at the first tapping period was of excellent quality and kept well; that yielded during the second and third tapping periods also at first appeared to be of satisfactory quality, but in the course of a few weeks many of the biscuits developed a marked tendency to 'tackiness'. This defect became more and more serious in the successive tapping periods until in the cases of certain trees it became impossible to get the latex to coagulate to rubber, and it dried up to a viscous, sticky, apparently resinous mass.

From the results of the trials at Bonasika, it appears that in the latex of the mature Sapium trees the formation of the true caoutchouc molecule is very slow, and that when this is possibly incompletely formed, the rubber has a very marked tendency to degrade to a commercially valueless sticky mass.

During the 1910 trials it was decided to ascertain whether the marked falling off in yield of latex and rubber from the lower parts of the trunks also characterizes the higher parts of the trees. Six trees selected for trial were re-tapped on the lower parts, below 7 feet of their trunks, and yielded only 2·7 oz. of dry rubber, whilst from the higher parts of the trunks, from 8 to 12 feet from the ground, 13·1 oz. were obtained.

The trees at Bonasika are now being given a very prolonged period of rest from tapping in the hope that they will recover the power of yielding commercially valuable rubber in fair quantity, and with the view that possibly more satisfactory healing of the excised parts of the bark may ensue during this long rest.

The foregoing deductions from the work done at Bonasika are only strictly applicable to *Sapium Jenmani* and *S. cladogyne* growing on the soil and under the climatic conditions there existent. There are reasons for believing that in healthy trees growing upon higher and naturally better drained soil than is that at Bonasika, the yields of latex and of rubber per tapping-period are far in excess of those obtained at Bonasika. We are, however, aware that the same tendency to 'tackiness' in the rubber yielded by repeatedly tapped trees characterizes that obtained from trees growing in the more favourable conditions as it does those at Bonasika

A few trees of Para rubber have been planted at the Reserve. These have made fair progress and it is proposed to plant up a further 2 acres during 1912-13.

Trials at the Pomeroon Experiment Station.

At the Pomeroon Experiment Station situated at Marlborough, Pomeroon River, about 3 acres of rubber has been planted. Para and Sapium rubbers were the kinds put out. They were planted from June to September 1910. They have been planted alone, but some beds of Para rubber have been interplanted with Forastero and Criollo cacao and with Robusta coffee. The Para rubber is thriving well and is making satisfactory progress, but the Sapiums are not doing so well. It is probable that the Sapiums will be re-supplied with *Hevea brasiliensis* as occasion offers. Experiments with the cultivation of different catch crops and with various cover crops are in hand, and the effect of different crops upon the growth of the rubber trees is being carefully recorded.

PART II. ESTATE PLANTINGS.

Experimental plantings of Para rubber on estates in different parts of the colony took place in 1897-9. Of the plants put out there exist to-day twelve trees at Plantation Diamond, Demerara River; five at the Government Agency. North Western District; over sixty at Plantation Noitgedacht, Demerara River; one at Plantation Coverden, Demerara River; and twelve at Plantation Canefield, Berbice River There are also nine trees in the Promenade Gardens, Georgetown; and one at the Botanic Gardens, Georgetown.

No further plantings took place until 1905-6. Since then a steady demand for plants has existed and trials have been made in many parts of the Colony. During the past three years a rapid increase in planting has taken place, and the situations

which are the best suited to the cultivation of rubber are becoming recognized. It has been successfully demonstrated by experimental plantings that large areas of British Guiana are eminently suited for the cultivation of Para rubber. There are several plantings on the river lands of the colony that are looking very promising, and increasing attention is being paid to this crop. Several large estates are being established on the Demerara, Essequibo, and Canje Rivers, while other cultivations are progressing on other river lands and on lands at the back of the sugar estates.

The following acreage returns collected by the Board of Agriculture indicate the progress of rubber planting in the colony :—

Year.	Acres.
1907-8 ...	416
1908-9 ...	556
1909-10	995
1910-11	1,740
1911-12	2,250

It is estimated that of the 2,250 acres now under rubber in the colony, fully 1,700 are planted with Para rubber. This is but a beginning, as there are fully 9,000,000 acres of easily accessible lands that are unalienated from the Crown, much of which is suitable for rubber cultivation and for the growth of other tropical products. These lands can be leased from the Government on very liberal terms.

To meet the demand for rubber plants, the Government have undertaken to import seeds, and to germinate them. The results of these importations are shown in the following table :—

Year.	Whence obtained.	How sent.	Seeds received.	Seeds germinated
1905	Para, Brazil	Sample post	50	Nil
1906	Botanic Gardens, Singapore	Parcel Post	1,200	900
1906	Ceylon	Freight	26,362	1,000
1906	Botanic Gardens, Ceylon	Parcel Post	500	100
1907	Botanic Gardens, Singapore	„ „	10,800	6,925
1907	Botanic Gardens, Ceylon	„ „	1,050	675
1907	Botanic Gardens, Singapore	„ „	52,000	42,100
1908	„ „ „	„ „	50,000	43,150
1908	„ „ „	„ „	30,131	21,609
1910	„ „ „	„ „	29,979	20,604
1910	„ „ „	„ „	55,176	38,754
1910	Forest Department, Perak, F.M.S.	„ „	200,666*	3,980
1911	Botanic Gardens, Ceylon	„ „	29,049†	1,944
1911	Botanic Gardens, Singapore	„ „	60,630	41,813
1911	J. H. Richards, Ceylon.	„ „	19,921	15,024
	Totals		567,514	238,578

A large number of seeds have also been imported from the East by planters privately both by parcel post, and also by freight. It has been demonstrated by these shipments that seeds packed in charred rice husks in tins with closely fitting

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* A special order placed by the Government on behalf of certain private parties. The tins containing the seeds were hermetically soldered and thus the seeds lost much of their vitality from fermentation changes.

† Packed 900 in a box in place of 500 to 600 as directed.

lids which have not been hermetically soldered, and shipped by parcel post will give satisfactory results. The above 567,514 seeds have chiefly been germinated under glass at the Botanic Gardens, Georgetown, in specially prepared coco-nut fibre refuse, and the young seedlings have been transplanted into baskets when they were about four to five days old. The majority of the plants have been put out into the field when from four to six months of age, but some have not been planted until they were twelve months old, if the weather conditions were not favourable. It has been found that the autumn crop seeds germinate better than spring crop seeds, and the young plants appear to be more vigorous. A germination of 86 per cent. was obtained with one shipment of autumn crop seeds from the Botanic Gardens, Singapore.

Trials have been made with different methods of planting, and now the seeds are usually sown horizontally to a depth of about ½-inch, with the 'facetted' surface downwards.

Stumps have been imported by private enterprise with varying success. Some shipments have been very successful, while others have more or less failed. From examinations of many shipments of stumps it appears that the stumps imported should not be more than ½-inch in diameter at the level of the ground. Stumps that have still a faint indication of green in the stem travel more successfully than those whose bark is entirely brown. All shipments of stumps are now examined by one of us at the port of entry in accordance with the following order made by the Board of Agriculture on April 12, 1911 :—

'Whereas it is enacted by Section 2 of the Importation of Plant Diseases Prevention Ordinance, 1903, that it shall be lawful for the Board of Agriculture to prohibit the importation of any seeds, plants, or any description of earth or soil, or any article packed therewith, which are likely to be a means of introducing into the Colony any plant diseases and to permit their importation under certain prescribed conditions, and whereas the Board of Agriculture have decided that the importation of all Para rubber plants, stumps and cuttings thereof from Ceylon, the Straits Settlements, the Malay States, Java, Surinam, Brazil and the West Indian Islands shall, owing to the prevalence of fungoid and other diseases, be subject to the following conditions :—

'(1) Para rubber plants, stumps or cuttings thereof from Ceylon, the Straits Settlements, the Malay States, Java, Surinam. Brazil and the West Indian Islands shall not be permitted to be imported in any description of earth or soil.

'(2) All Para rubber plants, stumps or cuttings thereof from the above-mentioned places to be inspected by the Government Botanist or by an officer of the Department of the Department of Science and Agriculture deputed by the Director for that purpose before being removed from the wharf or stelling at which they are landed and not to be removed from that place unless permitted by the inspecting officer in writing.

'(3) If, on such inspection, the Para rubber plants, stumps or cuttings thereof be found to be not free from pests or diseases of any sort the plants, stumps or cuttings thereof to be treated as the inspecting officer may direct before removal from the wharf. If they are found to be infected with any pests or diseases, which in the opinion of the Board of Agriculture are of a serious nature, the plants, stumps or cuttings to be destroyed under the supervision of the Government Botanist or of any officer of the Department of Science and Agriculture who may be deputed for that purpose.

'(4) If their removal is authorised by the inspecting officer the plants, stumps or cuttings thereof to be planted apart from the general cultivation and to be subject from time to time during twelve months from the date of importation to inspection by the Government Botanist or by an officer of the Department of Science and Agriculture deputed by the Director for that purpose. If the plants are found at any inspection to be suffering from any pests or diseases which in the opinion of the Board of Agriculture are of a serious nature, they shall be treated as may be directed by the Board, or they may be ordered to be rooted out or destroyed under the immediate supervision of the inspecting officer.

'On and after the date of this notice the importation into the Colony of Para rubber plants, stumps or cuttings thereof from Ceylon, the Straits Settlements, the Malay States, Java, Surinam, Brazil and the West India Islands shall be only under the above-mentioned conditions in accordance with the terms of Section 2 of the Importation of Plant Diseases Prevention Ordinance, 1903.'

Some seeds have been obtained from Surinam and some have been obtained locally. The supply of locally produced seeds is gradually increasing, as many of the trees planted previous to 1907 are fruiting regularly. It is hoped, however, that the quantity of locally raised seed will increase rapidly in the next few years, and then less difficulty will be experienced in raising sufficient plants to meet the demands of planters. In the meantime an agreement has been entered into with the Botanic Gardens, Singapore, for the supply of 150,000 seeds a year for the next five years.

Trees are being tapped upon three estates in the Colony. Plantation Noitgedacht has produced the largest amount of rubber. Its quality is excellent and the rubber has been well prepared. The samples sent from this estate to the Second International Rubber and Allied Trades Exhibition were awarded the Silver Trophy presented by the West India Committee for the best samples plantation Para rubber exhibited from the West Indian Colonies. They were reported upon by Messrs. Lewis and Peat as follows: 'Good, strong, clean, well-prepared Para biscuits, in good condition. The best specimens in this Court.'

Mr. Kelway Bamber's report on the British Guiana samples of plantation Para was as follows:—

'In the British Guiana section some excellent Para biscuits were shown, quite equal to any from the East.'

PARA RUBBER at Plantation Noitgedacht.
Age 11 Years.

These reports are distinctly encouraging, and the indications at present show that returns equal to those obtained in the East may be expected from Para rubber planted in the colony.

Sapiums are also being cultivated on some estates in the colony, and Ceara rubber is being tried in the Rupununi District to the far interior of the colony.

PART III. MISCELLANEOUS INVESTIGATIONS.

The investigation of the various kinds of latex-producing trees scattered throughout the vast forests of British Guiana was commenced by the late Mr. Jenman (Government Botanist 1879-1902) in 1880, and has been continued since that year. Four different kinds of Hevea are known to occur in the colony. The most widely distributed and the most prevalent in the easily accessible portions of the colony is *Hevea confusa*. This species has been closely investigated. It was first collected by the Schombergks and subsequently abundant material was examined for Mr. Jenman from the Mazaruni and Essequibo Rivers. There are several trees growing under cultivation in three localities in the colony, and opportunity was taken to investigate the tree and the product obtained from it when grown under cultivation . The wild indigenous trees were known to yield a weak, yellowish, plastic product of low commercial value, and it was recently ascertained that the yields of trees growing in the forests were too small to make their commercial exploitation practicable. Investigation of trees under cultivation verified the fact that this species was a low yielder, whilst the product was no better than that obtained from forest-grown trees.

A large number of the seeds of *Hevea confusa* were distributed from the Botanic Gardens, Georgetown, during 1882-7 to various Botanic Gardens and Stations of the tropics, and *Hevea confusa* is at present represented in several of them. *Hevea confusa* is growing in the Botanic Gardens, Trinidad, while other mature plants exist at Castleton, Jamaica, and at Paramaribo, Surinam, and Buitensag, Java.

An examination in 1909 and 1910 of material from Trinidad led to a very careful investigation of the various characters of *Hevea confusa* and of the Para rubber (*Hevea brasiliensis*). The trees have a different growth. The leaves of *Hevea confusa* are glossy, are not lanceolate like the leaves of *H. brasiliensis*, and generally have one or not more than two apical petiolar glands. The venation is also different. The barks of the trees of the two species differ considerably, that of *H. brasiliensis* varying from smooth to longitudinally grooved, while that of *H. confusa* is a very dark brown and is covered with numerous short blunt 'prickles'.

The flowers differ in several characters, but to determine them they have to be examined very minutely and carefully. The seeds are decidedly different. The seeds of *H. brasiliensis* are larger than are the seeds of *H. confusa*, and in section the

seeds of *H. confusa* are more or less triangular as are the seeds of practically all the other species of the sub-group to which *H. confusa* belongs. The facets are not so clearly marked, and the dorsal surface of the seeds of *H. confusa* is decidedly rounded. Several differences are also to be seen in the young seedlings, and in the early colourings of the petioles. It is comparatively easy to distinguish between the two species, when they are examined side by side in various stages of growth.

Early in 1911, further specimens which were received from Trinidad possessed characters that were neither typical *H. brasiliensis* nor typical *H. confusa*, and it was suggested that possibly they might be from trees which were hybrids between the two species. Subsequent investigations showed that such was the case, and therefore the necessity of keeping such species as *H. confusa*, which produce only low-grade products, away from plantations of Para rubber was emphasized. The question of hybridization in Heveas was raised by Dr. Huber at the Conference at the Second International Rubber and Allied Trades Exhibition, and it is probable that many of the problems of the Rubber Industry of Brazil and of the East may have a botanical explanation. From specimens shown by the Brazilian Government at the Rubber Exhibition there would appear to be many varieties of *H. brasiliensis*, and these variations seemed to have well-defined localizations. A thorough investigation of these varieties and of their products is being undertaken and should prove to be of considerable interest.

CASTILLOA RUBBER IN DOMINICA.

BY JOSEPH JONES,

Curator of the Botanic Station, Dominica,

AND G. A. JONES,

Assistant Curator.

Plants of Castilloa were introduced into Dominica during the year 1891. The original trees, four in number, are growing in the Botanic Gardens. They are now fine, healthy specimens over 60 feet in height with an average girth of 88 inches, 3 feet from the ground. For many years past the trees have yielded seeds in abundance. All the Castilloa trees in Dominica as well as those which are under experimental cultivation in Montserrat, Antigua, St. Kitts and the Virgin Islands are the progeny of the specimens at the Dominica Botanic Gardens.

The cultivation of Castilloa on estates, except in a single instance, has always been on a limited scale. At the present time the area under this cultivation is very small, although large supplies of seeds and plants have been available for distribution for the past fifteen years.

Recently, investigations respecting the genus Castilloa have been undertaken by the United States Department of Agriculture, and by the United States National Herbarium, with the result that, instead of the three or four species of this genus which were thought to exist, the number has been raised to ten or eleven. Until a short time ago, it was thought that only one species was being grown in the West Indies, namely *Castilloa elastica*; but as a result of the investigations mentioned, it has been ascertained that three, and possibly four, species are at the present under experimental cultivation in these islands.

It is known that the different types of Castilloa, in their habitats on the mainland, exist under varying conditions of climate and rainfall. Some are natives of dry localities, whilst others thrive in the humid situations, and they probably vary considerably in the yield of latex. These facts, only recently brought to notice, complicate the matter of Castilloa cultivation in these islands. The need of accurately determining the introduced species was at once seen and acted upon.

The first steps to secure the identificatin of the species were taken by the Agricultural Department of Jamaica. As a result of these efforts, it is known that two species are being grown in that island, namely, *Castilloa guatemalensis* and *Castilloa costaricana*. Following this action, herbarium specimens of the Dominica tree were forwarded, at the instance of the Commissioner of Agriculture, to the United States Department of Agriculture, Washington, in July last. Owing to the absence of Professor Pittier, the botanical authority on the genus, a preliminary examination of the specimens was under

taken by Dr. O. F. Cook, who writes to the effect that he regards the material as representing the true *Castilloa elastica* Cerv., of Eastern Mexico. The final determination will be made by Professor Pittier on his return from Panama.

In connexion with this question, it may be stated that a rubber planter engaged in travelling through the West Indies, a few months ago, made a close examination of the Castilloa trees, in the Dominica gardens, and he expressed the opinion that our species was not the same as the one cultivated in Trinidad. Possibly, the latter kind may agree with one of the species grown in Jamaica, or it may be distinct. In the latter case, it would be shown that no less than four types of Castilloa are under cultivation in the West Indies. Experiments are now needed in order to ascertain the yield of each kind, as well as the climatic conditions best suited to the respective species. The Castilloa grown in Dominica succeeds best on the lowlands with a high temperature and a moderate rainfall. Trials made in the wet districts show that it is far from satisfactory both in growth and in yield of latex.

Tapping.

The method used in Dominica for tapping the Castilloa trees is very similar to that in common use on estates in Trinidad and Tobago. A thin chisel about 1½ inches wide is used; this is carefully tapped with a hammer, care being taken not to strike it too hard. The cuts are made in perpendicular rows about 8 inches apart, each row about 4 inches from the other. The second row is made in the interval between the first and the third. The latex, which comes out in a fairly thick mass, collects around the cut, the accompanying black fluid flowing down the stem. The latex is then taken up with a spatula made of bamboo, put into small cups and transferred to earthernware vessels. In this way the trees are thoroughly tapped all round the stem in three or four operations. The trees may be tapped to any height. It is the custom in Dominica to bleed the older trees to a very considerable height, using a ladder for the purpose. The younger trees are operated on only to a height of about 6 feet from the ground.

By this method of tapping the injury to the tree is not very great, and though far from perfect, it seems the most suitable at present.

Preparation of the Rubber.

The latex collected in the earthenware vessels is brought in and diluted with clean water. It is then passed through muslin to remove impurities such as bark and dirt. The clean latex is now transferred to wooden buckets fitted with wooden stop-cocks at the bottom. Each bucket contains only about one-sixth its volume of latex; they are then filled with water, preferably hot, a few drops of formalin is added and latex is allowed to cream. The creaming takes place quite rapidly if sufficient water has been added. The water is withdrawn from below and a fresh supply added and again mixed with the latex. This process may be repeated three or four times until the

water withdrawn is quite clean. Sometimes, the latex coagulates of its accord in the bucket. Should coagulation not take place after the final lot of water is withdrawn, the thick cream is transferred on to a piece of muslin, and the water allowed to drain. After a few hours, a spoon may be used to bring the latex together, which with very slight working coagulates. The soft coagulated mass is well washed, and then placed between two boards and pressed to the required thickness, about $\frac{1}{8}$-inch. A very considerable pressure is sometimes required for this; there was only available for the purpose a disused letter press and this accounts for the somewhat unfavourable report of the experts at the recent Rubber Exhibition : some of the samples were reported upon as being uncured. The pressed rubber cakes are again washed and placed in a cool, dark place to dry.

The whole process, from the extraction of the latex to the preparation of the biscuits, need not take more than twenty-four hours, and the sooner it is completed the better. The rubber obtained is at first perfectly white, provided everything is kept scrupulously clean ; on drying it changes to a brownish colour.

A sample of rubber prepared as detailed above was forwarded to the Government Laboratory, Antigua, for analysis. It gave the following percentage results calculated on dry rubber : Caoutchouc 85·4, resin 11·9, proteid 2·6, insoluble matter 0·0, ash 0·0.

The report further stated : 'The colour of the sample was very good as also were its elasticity and tenacity.' As will be seen from the above, the resin content is somewhat high. In this connexion it may be stated that an experiment was conducted with the object of reducing the percentage of resins by washing the latex with a dilute solution of caustic soda. A sample of each was again forwarded to Antigua, but Mr. Tempany states in his report : 'Treatment with caustic soda appears to have had relatively little effect on the character of the sample.' The one washed with the soda contained 12·1 per cent. of resin and the unwashed 12·65 per cent. Further experiments with varying quantities of soda solution, are needed in this direction.

Yield of Rubber per Tree.

Having described the method of tapping and the process of preparing the rubber, there remains now to consider the yield obtained per tree. This is perhaps the most important factor of all.

Prior to April 1911, chiefly owing to the difficulty encountered in coagulating the latex, no records were kept of the yields obtained per tree, or per set of trees, in Dominica. Since then, however, the trees have been tapped regularly every three months, and the rubber weighed. It should be stated that all the trees were thoroughly tapped during February of this year, and the rubber shown at the Rubber Exhibition. They had had, therefore, close on three months rest before they were tapped the following April.

The Castilloa trees at the Botanic Gardens, for the purposes of tapping experiments, may be conveniently divided into three sets: (1) Four trees, twenty years old, having a girth at 3 feet from the ground of 7 feet 4 inches; (2) nine trees thirteen years old, with an average girth of 37 inches at 3 feet from the ground; (3) thirty-seven trees, twelve years old, with an average girth of 36 inches at 3 feet from the ground.

The first set of trees, four in number, were tapped to a very considerable height with the aid of ladders. In April they together yielded 1 lb. 13 oz. of cured rubber, in July 1 lb. 5 oz., in October 1 lb. 7 oz. and in January 1912, 1 lb. 2 oz. The trees in one year with four tappings have yielded 5 lb. 11 oz. of rubber or a little under $1\frac{1}{2}$ lb. per tree.

The second set of trees, nine in number, owing to their smaller girth were only tapped to about 6 feet or a little higher. They together yielded in April, 0 lb. 8 oz., in July 0 lb. $7\frac{1}{2}$ oz., in October, 0 lb. $3\frac{1}{2}$ oz. and in January 1912, 0 lb. 5 oz. The nine trees in one year with four tappings have yielded 1 lb. 8 oz. or 2·7 oz. of rubber per tree.

The third set, thirty-seven trees, were also tapped only to a height of 6 feet. They together yielded in April, 2 lb. 14 oz. in July, 1 lb. $3\frac{1}{2}$ oz. in October, 2 lb. 1 oz. and in January 1912, 1 lb. 8 oz. In one year with four tappings they have yielded 7 lb. 10 oz. or 3·3 oz. of rubber per tree.

RESULTS FROM EIGHT QUARTERLY TAPPINGS.*

No. of trees.	Age, years, 1912.	Average girth 3 feet from ground.		Actual yield in four quarterly tappings.		Average yield per tree during		Average annual yield over two years.
		1911.	1912.	1911.	1912.	1911.	1912.	
		ft. ins.	ft. ins.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.
4	21	7 4	7 $6\frac{1}{2}$	5 11	2 11	1 7	0 $10\frac{3}{4}$	1 1
9	14	3 1	3 $4\frac{1}{2}$	1 8	0 $8\frac{1}{2}$	0 2·7	0 1	0 1·8
37	13	3 0	3 6	7 $10\frac{1}{2}$	2 8	0 3·3	0 1·1	0 2·2

Similar tapping experiments have been conducted by the writers on four estates in Dominica, but in each case the yield of latex has been very small. On one estate, thirty trees over twelve years old, and tapped for the first time yielded 5lb. $8\frac{1}{2}$ oz. of cured rubber, this is slightly under 3 oz. per tree. On all the other estates, the yield obtained was much less.

*This table, recently forwarded by Mr. Jones, has been substituted for the one in the original conference paper, which contained the results for 1911 only. —[Ed. *West Indian Bulletin.*]

From the above estate it will be seen that the only trees which show any promise of satisfactory yields are the four oldest trees at the Botanic Gardens, the average yield per tree being just 1½ lb. These trees, however, are such well developed specimens that twenty-five would completely occupy an acre of land. When planted closer than this, the girth development is checked and the yield suffers in consequence.

Assuming, then, that twenty-five trees are grown to the acre, and that the yield per tree is 1½ lb. per annum, the total output of rubber, per acre per annum, would only be 37½ lb., valued at 3*s*. per lb. This comes to £6,—and this after twenty years of waiting and when the trees are at their best.

Reference is frequently made in agricultural publications to the large yields obtained from mature Castilloa trees on being tapped for the first time. We found this in Dominica; but once the trees are subjected to systematic tapping high yields are not obtainable. We also found that when the lower parts of the trees have been tapped several times, the period required for the cells to again fill with latex is a gradually lengthening one, and there are indications that ultimately the flow will cease almost entirely. This defect may not become apparent for two or three years as regards yield, for during that period an average return might be maintained by tapping new areas higher up the trunk of the tree.

Suggestions are sometimes made to the effect that a low yield of rubber per tree may be turned into a fair yield per acre by planting at the rate of from 300 to 400 trees to the acre. An experiment conducted on these lines did not prove satisfactory.. Close planting results in the weakening of a number of seedlings and their suppression by those more strongly-growing. After eight years, the plot consisted of a number of attenuated trees of small girth and of poor latex-yielding capability.

It is well-known that established Hevea trees will give average yields of several pounds of high class rubber per annum, which obtains the highest prices in the market. On the other hand, experts agree that an average yield of ½-lb. of rubber is all that is to be expected from ten- or twelve-year-old Castilloa trees, and the latter rubber is regarded by buyers of moderate quality, and is valued accordingly.

Given suitable conditions, Castilloa trees, both when young and when mature, are fine examples of vegetative vigour during the growing season. From the outset they are well branched and of good girth measurement, and form a striking contrast to the somewhat slender-looking Hevea of the same age. Their promising growth has probably been regarded by growers as indicating a good yield of latex when they become mature. Unfortunately, experiments have not borne out this view.

In the numerous contributions made recently to agricultural journals on the subject of tapping Castilloa, and on preparing the rubber, great stress is laid on the labour conditions obtaining in the West Indies. The importance of growing a rubber tree, which needs three or four tappings

a year only, is contrasted with the Para rubber tree and its requirement of 120 tappings or more annually. No doubt the question of obtaining good labour for tapping Hevea trees and the expense of such labour is serious, but equally serious is the low yield of the Castilloa trees, which appear to be recommended for cultivation largely on account of the small amount of labour required for tapping. In the case of the Hevea trees there is a steady flow of latex nearly all the year round, in Castilloa there is no wound response, the available latex being collected by tapping the trees at intervals of three or four months. Further, in making statements as to the number of tappings the respective species require, and the relative cost, writers conclude that it takes the same time to tap a Para rubber tree as a Castilloa tree. But we do not agree with this; our experience inclines us to think that a number of Hevea trees could be tapped in the same time as is required to deal with a single Castilloa tree. Again the tapping, collection of latex and preparation of Para rubber are simple, quick and cleanly operations when compared with similar work in connexion with Castilloa trees. In the former case a sound system of treating the trees has been developed; in the latter, many problems still remain to be solved.

It is obvious that, as far as conditions in Dominica are concerned, we cannot recommend, as a result of these trials, the cultivation of *Castilloa elastica*; and it is a matter for congratulation that, with perhaps one exception, no planter in Dominica has undertaken the cultivation of this species of the rubber-producing plants. At the present time, the Para rubber, *Hevea brasiliensis*, still remains, after years of experiments with other rubber trees, the only one that has given general satisfaction under cultivation.

NOTES ON THE CULTIVATION OF PARA RUBBER.

BY F. EVANS,

Assistant Superintendent and Curator,
Royal Botanic Gardens, Trinidad.

Hevea brasiliensis will thrive from sea level, to an elevation of about 3,500 feet; over 1,000 feet, however, the growth, as on some of the Java plantations, is somewhat slow. The chemical properties of the soil are not of great importance, and with avoidance of loose sand or gravel on the one hand, and swamp land on the other, the tree will grow well in almost any kind of soil providing there is an evenly distributed rainfall of not less than 70 inches per annum and a minimum temperature of 65° to 70° F.

The seeds may be planted at stake, but the general custom is to sow in nurseries and transplant as stumps six to twelve months old. Some planters are now reverting to the preferable practice of planting from baskets or pots. In Malay, the stumps are planted without shade in full exposure to sun and wind.

In the East, planting distances vary considerably; 8 feet × 8 feet (680 per acre), 10 × 10 (435 per acre), 12 × 12 (302 per acre), 15 × 15 (193 per acre), and 20 × 20 (108 per acre) have all been given a trial. The general tendency is now toward wide planting and 24 feet × 24 feet, 24 × 12, or the avenue system 30 × 10 are gaining in favour. Some of the disadvantages of close planting are that it retards the growth of the trees, hinders bark renewal, and prevents the admission of sunlight thus aiding the spread of fungus diseases; these arguments apply with equal force to the interplanting of such permanent crops as coco-nuts and cacao. A circumstance against wide planting is that, during the first few years of tapping, the closely-planted fields give a higher yield per acre.

Drainage is an important factor in the successful cultivation of Para rubber, especially where the soil is of a retentive nature. On a plantation near Penang, recently visited, 3½-year-old trees, on well-drained land, gave an average circumference of 19 inches, 3 feet from the ground; whilst trees of the same age on undrained land, otherwise similarly treated, gave an average circumference of 14½ inches, 3 feet from the ground.

In the Malay States, clean weeding is the general practice and costs from 30c. to 90c. (Malay money) or about 16c. to 50c. (West Indian money), per acre. The high cost of labour practically prohibits this form of cultivation in the West Indies, it is moreover an open question whether it is wise or necessary; for as shown by the following figures, measurements recently taken of trees growing in an unweeded, but well drained Trinidad plantation compare very favourably with measurements of trees growing in the Federated Malay State, under the Eastern plantation condition, namely, clean weeding

Girth measurements, 3 feet from the ground, of trees growing on Non Pareil Estate, Sangre Grande, Trinidad, planted 14 feet

× 14 feet, and interplanted with cacao at the same distances, shaded with the Immortel (*Erythrina velutina*), planted 28 × 28, gave :—

2-year-old	...	...	...	...	7	inches
3 „ „	...	...	...	...	13½	„
5 „ „	...	...	...	...	18	„

The average measurements of trees on three clean weeded Malacca plantations were :—

2-year-old	...	...	...	...	8	inches
4 „ „	...	...	...	...	14	„
5 „ „	...	...	...	...	16	„
7 „ „	...	...	...	...	24	„

The average measurements of trees on 2 plantations in Kuala Selangor, F. M. S., were.

3-year-old	...	...	...	...	12½	inches
4 „ „	...	...	...	...	18½	„
5 „ „	...	...	...	...	20	„

According to Dr. Ridley, late Director of the Singapore Botanic Gardens, the annual girth growth of a healthy, well-grown Hevea tree should be as follows :—

1st	year	...	—	inches	11th	year	...	60	inches
2	„	...	9	„	12	„	...	66	„
3	„	...	14	„	13	„	...	72	„
4	„	...	20	„	14	„	...	78	„
5	„	...	24	„	15	„	...	80	„
6	„	...	30	„	16	„	...	82	„
7	„	...	36	„	17	„	...	84	„
8	„	...	42	„	18	„	...	86	„
9	„	...	48	„	19	„	...	88	„
10	„	...	54	„	20	„	...	90	„

At Taiping, F. M. S., there is a tree, said to have been planted about twenty-five years ago by Sir Hugh Low, which measures 122½ inches, 3 feet from the ground.

In Trinidad the use of green manures or cover crops will probably be found more profitable than clean weeding. Unfortunately, the ideal cover crop, able to successfully keep down grass and to grow and thrive under shade conditions, is as yet undiscovered.

Secondary or catch crops such as cassava, coffee and ground nuts, help considerably in keeping down weeds and may be profitably grown on ' wide-planted ' estates. In Java *Coffea robusta* and the cocaine plant (*Erythroxylum Coca*) are much favoured as intercrops, and on one plantation in the Federated Malay States, good returns are being obtained from the ipecacuanha plant (*Cephaelis Ipecacuanha*).

Topping or thumb-nail pruning, at one time recommended with a view to increasing the circumference of the tree, is not now advocated, experience having shown that the side or lateral branches thrown out are brittle and easily broken by winds, causing ragged wounds. The low, spreading branches caused to form by such pruning also interfere with tapping operations.

Under favourable conditions, trees become tappable in from four to six years ; speaking generally they are tapped, irrespective of age, when about 18 inches in girth, 3 feet from the ground. In Malacca, trees 14½, 15, 16, and 17 inches in girth, 3 feet from the ground, are being tapped, and it is claimed that the tapping, if expertly carried out, does not damage the tree nor interfere with its growth ; the rubber, however, from very young trees is somewhat inferior in quality.

The first year's tapping is usually a basal V, 12 to 20 inches from the ground and extending half-way round the tree. For subsequent years, of the numerous methods in vogue, the ¼-or-½ surface herring-bone system appears to be the best. While the ½-surface gives the greater immediate return, experience goes to prove that the ¼-surface is best for the tree and allows for a more perfect bark renewal.

There is no advantage in tapping high up the tree, it demands an undue expenditure of labour, and the latex is inferior to that obtained from the base. The cuts should be made no higher than a man's reach and the daily shavings should never be less than twenty to the inch.

Of the many tools now on the market, the simplest in make and design are preferable and those now in general use on Eastern plantations are the Farrier knife and the ½-or ¼-inch bent gouge chisel.

Throughout the East, good workers tap 250 to 300 trees per task, working seven to eight hours per day. Boys and women do 150 to 200 trees per task. For marking out and opening cuts, the task is usually forty to fifty trees per day. The price paid per task ranges, according to locality, from 25c. to 50c. (Malay money), or 14c. to 28c. (West Indian money).

For rubber to be a commercial success in the West Indies tappers should not be paid more than 30c. to 40c. per task of 250 to 300 trees.

Yields vary according to local conditions ; under favourable Malayan circumstances, 1 to 2 lb., from five to six year old trees, with an increase of ½-lb. per annum to about the 10th or 12th year, appears to be a reasonable expectation.

It is probable, however, that yields in the West Indies will be considerably lower, as the average rainfall is less and not as evenly distributed as in the Malay States.

On Batu Caves plantation, F.M.S., a field of eight-year-old trees gave an average of 6 lb. of dry rubber per tree ; and according to McMillan, ten trees on Culloden Estate, Ceylon, about twenty-two years old, gave an average yield of 18 lb. per tree, and a thirty-three year-old tree in the Heneratgoda Gardens, Ceylon, yielded in 1909, 98 lb. of dry rubber.

On the best conducted Eastern plantations the rubber in the shavings of the daily cuts is extracted and turned into crêpe, and in some cases pays the cost of tapping. Unfortuately this very important point has been overlooked in the experiments carried out in this island, consequently we have no reliable data as to the actual yield of Trinidad trees.

We have sufficient evidence to show that certain districts in some of the West Indian islands are well suited to the cultivation of Para rubber; but in face of the limited area available, the comparatively high cost of labour, the probable lower yields and the possible fall in the price of the raw article, it is unlikely that the industry in the West will ever possess the enormous success it has gained in the East. In the Malay States, Ceylon and Java the cost per acre of bringing rubber trees into bearing ranges, according to locality and the nature of the land, from £20 to £35.

In this island, there is no unmixed plantation of Hevea which can be used for comparison, but the following estimate which has been furnished by a planter who has had considerable West Indian experience in planting cacao and rubber, gives some indication of the probable cost per acre in Trinidad.

ESTIMATED COST OF PLANTING AND CULTIVATING 1 ACRE IN HEVEA RUBBER, FOR 5 YEARS, IN TRINIDAD.

1st year.	Cost of land	$12·00	
	Felling forest trees	4·80	
	Clearing and burning same ...	7·70	$24·50
	Lining and cutting pickets, etc.		
	20 feet × 15 feet	1·05	
	Cost of 145 rubber plants, at 3c.	4·35	
	Planting rubber	1·20	
	Planting cover crops	2·75	
	3 weedings	5·80	15·15
	Supplying, etc.	1·00	
	Draining and round-ridging	18·00	
	Supervision, taxes, etc. ...	10·00	29·00
			68·65
2nd year	3 weedings	4·40	
	Supplying, etc.	1·20	
	Supervision, taxes, etc. ...	10·00	15·60
3rd year	3 weedings	4·00	
	Supplying, etc.	1·20	
	Re-opening drains	9·44	
	Supervision, etc.	10·00	24·64
4th year	3 weedings	3·60	
	Supplying etc.	1·20	
	Cleaning drains	10·00	14·80
5th year	2 weedings	1·80	
	Supplying etc.	1·00	
	Cleaning drains	7·50	
	Supervision, taxes etc. ...	10·00	20·30
			143·99
	10 per cent. Contingencies ...		14·39
	Total		$158·38

To the above figures may be added 8 per cent. interest on each annual outlay, and $2,000 for the factory.

The upkeep of a plantation after the first five or six years is comparatively small, and under Eastern labour conditions, rubber costs about 1*s.* to 1*s.* 6*d.* per ℔. to place on the market, including all charges after the tapping stage is reached.

The following estimate will give some idea of what the cost of tapping and upkeep will be in Trinidad.

ESTIMATED COST OF ANNUAL UPKEEP AND HARVESTING RUBBER FROM 250 ACRES PLANTED 20 × 20 FEET.

Marking out 27,000 trees, at 40c. per task of 50 trees	$	216·00
Daily tapping of 27,000 trees, at 40c. per task of 250 trees		15,768·00
Factory : 6 men at 40c. and 10 boys at 20c. per day, 300 working days		1,320·00
Manager, at £400 per annum		1,920·00
Two Overseers at £150 per annum		1,440·00
Cleaning and opening drains, at $6·00 per acre ...		1,500·00
3 brushings at $1·20 per acre		900·00
Taxes on 250 acres at 24c.		60·00
Tools, office and contingencies		2,000·00
Total	$	25,124·00

Placing the average yield in Trinidad at 200 ℔. per acre, the cost per pound, as shown by the above figures, which does not include agricultural tax, duty or freight charges, will approximate 50c., or 2*s.* 1*d.*, and providing the price of rubber does not fall below $1·00, this will leave a reasonable profit.

NOTE ON THE PRESENT POSITION OF RUBBER IN GRENADA.

BY G. G. AUCHINLECK, B.SC., F.C.S.,

Superintendent of Agriculture, Grenada.

The cultivation of rubber in Grenada has never assumed very large proportions, chiefly owing to the fact that most of the available land of value has long been occupied by cacao. From time to time specimens of various rubber trees have been received by the local Department and established at the Botanic Gardens or distributed for trial among the planters in different parts of the island. At present the species which are cultivated on a commercial scale are *Hevea brasiliensis* and *Castilloa elastica*, while specimens of *Funtumia elastica*, *Manihot Glaziovii*, *M. dichotoma* and a Landolphia are established at the Botanic Gardens. A few Funtumias have also from time to time been sold or distributed from the Gardens.

It is difficult to form any estimate of the areas under Hevea and Castilloa, as small lots of seed have continually been purchased or imported by planters, and the cultivation is very scattered. The largest area on a single estate is that of Mr. Grahame Lang at Tuilleries Estate: Mr. Lang, who must be regarded as the pioneer of Hevea planting in Grenada, has about 30 to 40 acres of all ages from seedlings to trees four years old. In all about 100,000 to 150,000 seeds have been imported into the island in the last four years, of which about 20 per cent. have grown. An estimate of 20,000 to 25,000 established plants equivalent to 100 acres of cultivation would not be far from the correct figure.

Castilloa cultivation probably does not exceed 40 acres, only one estate in the island having entered upon it on a small commercial scale.

Increase in the cultivation of Hevea has received serious set-backs through the rapid deterioration of the seed in transit and the consequently poor germination results obtained in the majority of cases. This, added to the fact that the cost of the seed throughout the period has been very high, has hindered any rapid development. In 1910 and 1911 seeds cost 2½*d.* each in Trinidad and even then were unsatisfactory in germination, representing a minimum initial outlay per acre for seed of over £2.

Germination results on imported seeds have varied enormously according to the method of packing and transmittal. In 1911, the local Department ordered 75,000 seeds from the Ceylon Botanic Gardens at a cost of over £70: careful tests at the Grenada Gardens gave a germination of 12 per cent. These seeds were packed in dry charcoal in open tins. In 1907 a lot of 12,000 imported from Ceylon through the parcel post by Mr. Lang gave a germination percentage of over 80. Eleven thousand seeds reaped from the trees at the Grenada Botanic Gardens and planted immediately gave 800 plants (72 per cent. So far as can be judged by results, the best method of

transmitting the seeds for long distances is to pack them in damp charcoal in sealed tins and transmit them rapidly by parcel post.

Methods of Cultivation.

Hevea seeds have been treated in various ways by planters; in a fair number of cases they have been planted at stake, with varying results: drought in these cases is a source of great loss, whereas in suitable weather, germination compares very favourably with that obtained in specially prepared beds. One method followed with a considerable degree of success was the use of a cacao-drying drawer filled with river sand as a seed-bed. The seed grown at the Botanic Gardens was germinated in concrete-framed nursery beds made of one part washed sand and two parts ordinary garden soil. A heavy wet soil or a dry soil are regarded as equally harmful to the seeds, and seed-beds should be light in texture with a sufficient supply of moisture.

The cultivation of Hevea in Grenada has hardly reached a stage where methods can be compared, but as a general rule the plants have been set out in 'scrub' or low bush, the planting holes being the only parts of the soil broken up. Attention after this merely consists of periodic clearing of areas round the trees, the areas extending 2 to 3 feet from the trunk. Mr. Lang in one field has inter-planted pigeon-peas with the cultivation. The distance of planting varies from 12 feet to 20 feet square. The question of special manures has not yet been tried.

The growth of Hevea has been satisfactory in most cases: many of Mr. Lang's trees at four years old were 20 feet high with a diameter at the ground-line of quite 5 to 7 inches.

So far there have been no planting of 'stumps' and practically no systematic topping of trees.

The elevation at which Hevea and Castilloa are now being tried range from sea-level to an altitude of 1,400 feet.

Castilloa grows remarkably readily all over the island although it shows a marked tendency to great irregularity in stature. This irregularity appears in some cases to be inherent in the plant and not solely due to differences of soil. The plant sows itself naturally and multitudes of young seedlings are always available from the under-growth of the cultivations.

Diseases.

So far, Hevea has been quite free from disease: no insect attacks or fungoid pests have been recorded in Grenada. Castilloa suffers rather severely from attacks of a mealy-bug under the leaves, but the periodic leaf-fall lessens the damage very considerably. A more serious disease is fungus in nature, and attacks the stem at the ground line destroying the bark and finally ringing the trunk and killing the tree. The fungus has been stated by Mr. F. W. South, Mycologist to the Imperial Department of Agriculture, to be probably a Rosellinia, and it has been found attacking, in nature, trees and plants about one-

year-old. From observations of this fungus one is inclined to think that it may be a dangerous menace to Castilloa in wet districts.

Results of Tapping.

To date, there has been no tapping of Hevea on a commercial scale. A couple of mature trees were tapped with a Golledge knife at the Botanic Gardens in 1911 with practically no results: drought reduced the flow to a negligible quantity and it was not found possible to obtain even a hand sample.

Castilloa has been tapped on a fair scale on one estate and samples shipped, but figures are not available. A small hand sample from two trees at the Botanic Gardens showed a content of 80 per cent caoutchouc, the sample being coagulated with acetic acid; the actual analysis was as follows:—

Resins (acetone extract)	16·65
Caoutchouc (by precipitation) ...	80·05
Ash	1·41
Loss on washing	2·1

The Golledge knife, which cuts shallow groves in much the same manner as might be expected from a narrow carpenter's plane, has not been found very satisfactory for Castilloa. The dragging cut tends to close the latex channels and stop the flow. Another instrument, manufactured in Trinidad, appears slightly more promising: it is in reality five narrow chisel blades placed in a row on a handle, and used as a pricker.

Possibilities of Development.

There are so many factors to be taken into account that in the absence of experience, any attempt to foretell the chances of rubber becoming an important industry in Grenada must be made with extreme care. Actual increase in cultivation must be definitely limited to a comparatively small area owing to the existing extensive areas in cacao. So long as cacao continues to fetch its present price, averaging anywhere from £8 to £20 per acre, there seems little chance of its replacement by rubber. At present, and probably for years to come, rubber cultivation will be limited to waste lands on the outskirts of cacao estates. Mountain lands will be expensive to work and to manure, and the trees will presumably suffer from epiphytic and mossy growths to the same extent as cacao.

The suitability of the soil to rubber has not yet been determined. The Hevea plantation at Tuilleries estate is growing well in a reddish soil, the chief characters of which are sensibility to drought and wet and a capacity for using large quantities of manure. There are also several individual cases of Hevea thriving luxuriantly on the alluvial banks of streams. Castilloa on the other hand is exceedingly irregular in growth on all the plantations, and in wet lands suffers from fungoid root disease.

Note on Experiments with Hevea Seed.

In closing this paper, mention should be made of certain observations carried out at the Botanic Gardens in connexion with the germination of Hevea seed. A tendency towards irregularity in the seed capsules was noted in the case of two mature trees : capsules were generally three-seeded, but a small percentage occurred of two-seeded and four-seeded fruits, seeds from abnormal capsules have been planted in order to see whether they will give rise to trees having different varietal characteristics.

Weight test of seeds, side by side with germination tests were carried out in the laboratory, and the conclusion was finally reached that loss of germination power is coincident with, or caused by, loss of moisture. The average weight of a normally fertile seed was found to be 4·9 grams, and the loss in air amounted to 20 per cent. in fifty days.

The loss of weight occurs in many cases while the seed is in the capsule, as was proved by the fact that of 1,100 seeds reaped on the first sign of ripening before the capsules dehisced, nearly 300 were light in weight, and did not germinate.

This point is of importance in view of the fact that capsules are usually allowed to dehisce before the seeds are gathered, and the vendors of the seed do not as a rule attempt any selection by weight.

RUBBER CULTIVATION.

By Dr. P. J. S. Cramer.

Director of Agriculture, Surinam.

Dr Cramer's lecture was illustrated by numerous fine pictures.

The first set of slides gave an idea of the opening work. The cutting of the wood and the further cleaning by burning and second burning was shown. In the East great attention must be paid, said the lecturer, to the opening, as there occurs a dangerous disease, caused by a fungus, living upon decaying wood as well as on the roots of the rubber trees. Therefore, if decaying wood is left in the soil, the root fungus may appear and attack the Para rubber, spreading through the whole field; if once present, a good deal of money has to be spent in cleaning the soil again and in treating the diseased trees. Views of the fungus itself and of methods to keep it under control were shown and explained. Dr. Cramer said that up till now the root disease had not been found in this part of the world, but a well carried out clean opening would always be to advantage of the rubber.

Discussing the different conditions of soil and climate Para rubber requires, Dr. Cramer said that Hevea prefers a low country climate to a high altitude above sea-level. At about 2,000 feet the growth is poorer than in the lower land. If planed on hills, attention must be paid to avoid erosion; an example was shown of a tree, the roots of which were above the soil owing to the washing off of the top soil by rain. The original idea was that Hevea would like swampy soil; experience has shown that this is not the case, and that Para rubber requires well-drained soil; a depth of at least 3 feet is necessary. Views of plantations to show the drainage systems were then put on the screen.

Coming to the raising of the planting material, attention was drawn to the occurrence of large variations in the growth of the trees. Sometimes exceptionally thick trees are found; an example of such a tree was shown, the lecturer pointing out that it is advisable to choose these trees as seed-bearers. The seeds, he continued, are left in wet sand or a similar material, and as soon as they germinate are put out in seedling beds. These may be shaded sometimes in the beginning; it is better to leave them afterwards quite open. Unshaded beds give stronger, thicker and hardier plants than shaded ones. The most generally practised way of planting in the East is the planting of stumps. The laying out of the fields has to be done carefully. The trees must be planted in straight rows; this makes the upkeep in the first year easier and allows afterwards a better control of the tapping. In the fields a sufficiently developed road system is necessary; of course, a system of navigation trenches, as might possibly be laid out here, is even preferable, as it enables an easy and safe transportation of the latex. Sometimes, in exposed places, wind belts are necessary, as Para rubber

suffers a good deal from wind. A strip of the original wood may be left, or a special belt of some bushy tree may be planted.

The planting was then explained: the planting of stumps, the bad result of not thinning out the new shoots of the stump, and of leaving more than one stem or one root were illustrated. A view in a two-year-old field showed the differences among the trees as to their tendency to branch. Formerly, the stems were often tapped to stimulate branching, but, as was shown in a view of a five-year-old-field, the result is that the trees get a candelabra form, and the crown becomes too heavy, so that branches often break off. It is therefore better to allow the end bud to grow on, and to stimulate the growing of the other buds into branches by taking off the top whorls of leaves.

Para rubber requires a good upkeep. It is a mistake to think that it can stand weeds and grass. In the East, clean weeding is generally practised, as was shown in several slides. Sometimes on flat loose soil, a cultivator can be used. There is no doubt that clean weeding constitutes the cheapest method of upkeep, if well carried out. The weeds are pulled out before they can form seeds and so after a time are practically cut out. In the East, the lalang, a hard, stiff grass, is particularly dangerous to the rubber fields; if the upkeep is neglected it spreads quickly and the rubber trees are at first kept back and even die out. In older fields weeds do less harm, but still many full-grown, tapped fields are kept up by clean weeding. But what is possible in the East is not always practicable here. For several reasons clean weeding cannot be recommended for places like British and Dutch Guiana. Our soils are too stiff, so that it is impossible to pull out the weeds with the root; the part remaining in the soils soon sprouts again. Then, our rubber trees do not form the same heavy crown as they do in the East; four, or five-year-old trees of about the same girth as those in the East have a far smaller, more open crown, and do not shade the soil so thickly. And it cannot be thought safe to expose our soils to the bare sunlight. Therefore we must look after another system of upkeep, - covering the soil with a special cover plant, or growing another crop between the rubber trees. A series of slides showed different kinds of leguminous cover plants as inter-crops for rubber and attention was drawn to coffee and bananas, which were shown in several views. Other crops, said Dr. Cramer, like cassava and sugar-cane, are not fit for growing among rubber as they keep the rubber back.

The subject of tapping was illustrated by numerous slides showing various tapping systems, the effect of bad tapping, the way of using different kinds of tapping knives and experiments with high tapping. The series closed with a photograph of an old rubber-tree in Ceylon, which gave in 1909, a net profit of 23 guineas; but veterans like this, thirty-three years old when it was photographed, were said to be rare.

The curing of the rubber was then dealt with, views in the factory on a rubber estate, showing the coagulation of the latex, the rolling of the crêpe and a drying house closed the lecture.

FORESTRY IN TRINIDAD.

BY C. S. ROGERS,

Forest Officer, Trinidad and Tobago.

Forestry in Past Times.

In the old days, forests were considered an encumbrance to be got rid of as soon as possible, in order to make room for crops for the sustenance of man. The early clearings made, being small in comparison with the total wooded area of any country, produced no visible harmful effect. The result was that forests were indiscriminately cleared, until the damage done became so plain that a demand for conservation arose. Naturally, the effects of the destruction of forests were not apparent till many years after the clearance had been made, and probably the results were at first attributed to other causes. The first areas cleared were allowed to revert to forest, after a few crops had been grown, and the harm done was of little consequence.

Gradually, however, the clearance became larger and more permanent, with the increase of population and better methods of cultivation; and the areas denuded spread over considerable tracts of country before the results became noticeable, and streams that formerly were permanent became intermittent. Droughts and floods followed one another, increasing in intensity until they could no longer be ignored. Comparison of denuded areas with those where forests still remained, followed, and in course of time the real effects of forests were understood.

Timber, too, became scarce in localities where the population was dense, and had to be brought from considerable distances. The increase of transport facilities at first rendered this of little consequence, especially while there were large tracts of country where the forests were still considered an encumbrance. The inconvenience became greater as the areas from which timber could be obtained decreased, and in time a demand arose for the cultivation of timber as a crop, as well as for the reservation of forests for the protection of water-supply. In many cases, of course, both these objects could be attained on the same areas, and more especially in localities near the places where timber as well as water were required; that is to say, in the more populous parts of the world. Consequently it was in these that forestry was first developed, and to which we must look for guidance. Fortunately for Trinidad, the destruction of forests had not become very serious before attention was drawn to the need for conservation, the experience of older countries being then available for guidance in the methods to be adopted. In the western part of Trinidad, and in the south-western part of Tobago, clearance has gone farther than is desirable, and the reduction of the permanent supply of water in the rivers is causing some inconvenience.

Up to 1890, forest conservation had not really been attempted, though attention had been called to the matter by the Sub-Intendant of Crown Lands, Mr. (now Sir) David Wilson as far back as 1880. Before that, regulations controlling the cutting of timber under licences had been in force, but nothing had been done to replace the trees cut. In 1880, in response to a despatch from the Secretary of State for the Colonies, a Report on Forest Conservancy was drawn up by the late Mr. J. H. Hart, Superintendent of the Royal Botanic Gardens, Trinidad, in which it was stated that a permanent scheme of forest conservation was urgently demanded for the benefit of the island, that forest reserves were needed for the protection of water-supply and the growing of timber, that denuded areas should be re-afforested, and that though these measures were likely to be unpopular, their adoption was becoming urgent. No definite proposals were made for forest reservations, but reference to authorities in England was recommended, who, it was suggested, might draw up a scheme to be adopted and carried out by the Colony. Regret was also expressed that Mr. Cooper, an Officer of the Indian Forest Department, who reported on other West Indian Colonies some five years previously, had not been invited to visit and report on Trinidad while he was in the West Indies.

Nothing further appears to have been done till 1900, when Mr. F. A. Lodge, of the Indian Forest Department, at the request of the Government, visited and reported on Forest Conservancy in Trinidad and Tobago. Mr. Lodge's Report, published as Council Paper No. 62 of 1900, included definite recommendations for the reservation of 293 square miles, or 16·74 per cent. of the area of Trinidad as forest reserves, and 3·9 square miles or 12 per cent. of Tobago, where, at any rate on paper, a considerable reserve already existed.

In the following year (1901) an Officer from the Provincial Branch of the Indian Forest Department, having eight years' service, was appointed Forest Officer. He arrived in July 1901 and still holds the appointment.

Obviously, the first work to be undertaken was the demarcation of the Forest Reserves proposed in the Report of 1900. These proposals had not, however, been accepted in their entirety by the Government. The reserves were considered larger than the necessities of the Colony demanded. It was also thought that too great an area of good land had been included in the reserves, while much poor land not fit for cultivation might have been taken instead. Eventually, it was decided to reduce the area of the reserve in the mountainous northern part of Trinidad, so as to include only land situated over 1,000 to 1,200 feet above sea-level in the valleys, and over 800 to 900 feet on the spurs, thus leaving out the land most suitable for cultivation, and allowing for the extension of agricultural settlements.

This principle could not, however, be applied to the other reserves, as the ground on which they were situated did not contain hills of sufficient continuity or elevation. It was therefore decided to lay the remaining reserves substantially

as proposed in the Report of 1900, and when demarcation was completed, to examine them carefully, and select the areas necessary as final reservations and open the remainder to settlement. These preliminaries having been settled, demarcation actually began in 1902-3.

Demarcation.

The reserves in localities where the demand for land was most urgent were demarcated first, and as each reserve was laid out, the surrounding land became available for settlement. The reserves, with the exception of the eastern part of the Northern Range Reserve, were surveyed as they were demarcated.

As demarcation proceeded, and the demand for land became less pressing, it was found possible to select some final reservations, in place of the proposals of the 1900 Report, and thus at least in some places, the cost of doing the work of demarcation twice over was avoided. While the work was going on, considerable knowledge of the topography of the island, not recorded on existing maps, was obtained, and the necessity for some additional reserves became apparent. It was not, however, intended to increase the total area of the reserved forests, as the eventual reduction of some of the reserves proposed in the Report of 1900 would open to settlement more land than was included in the new reserves. It was evident that the selection and demarcation of these new reserves was a pressing necessity, if the opportunity for setting them aside was not to be lost. The demand for agricultural land was not yet satisfied, and in fact had been increased by the prospect of railway extensions, and also by the greater interest in the prospects of petroleum.

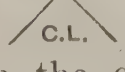
Consequently, it became necessary to lay out the new reserves before the reduction of the older ones was proceeded with. These new reserves consist of belts about one mile wide along important watersheds, and for the most part lie in the poorly watered southern part of Trinidad. They are designed to protect the supply of water in the upper parts of the streams taking their rise in the ridges forming the watersheds. The hills forming the ridges being of small elevation, the work of tracing them through the dense evergreen forests where an outlook of any extent is unobtainable was a matter of no small difficulty.

Incidentally, while they were being traced, more than one hill suitable for a trigonometrical survey station was found, and topographical information, not recorded on existing maps, though of considerable value in connexion with future road construction, was obtained and furnished to the proper authorities. The whole of these additional reserves have not yet been selected and demarcated, and we may be said to be still in the period of demarcation. The following table shows the present state of the work of demarcation :—

Name of Reserve.	Estimated area in Lodge's Report of 1900. Sq. miles.	Actual area by survey. Sq. miles	Length of boundary lines. Miles.	Gain. Square miles.	Loss. Square miles.
Northern Range ...	100	60 *	167 †		40·00
Central Range ...	76	62·04	54		13·96
Morne L'Enfer ...	16	17·47	17·75	1·47	
Cat's Hill	30	31·98	24·25	1·98	
Trinity Hill ...	22	26·28	21·75	4·28	
Arima	3	2·86	18·00		0 14
Tumpuna	8	8·38	13·50	0 38	
Wind Belt ...	11	8·38	24·50		2·12
Siparia New ...	8	17·49	35·75	9·49	
Southern Watershed					
Erin	§	8·18	19·25	8·18	
Mayaro	§	12·50	29·25	12·50	
Total, Trinidad...	274	256·06	425·00	38·28	56·22
Tobago ...	4	10·01	26·88	6·01	...
Total, Trinidad & Tobago ...	278	266·07	451·88	44·29	56·22

* Estimated, not surveyed.
† Demarcation not completed.
§ New Reserves not included in Mr. Lodge's Report.

The Caroni, Oropuche and Nariva Mangrove Swamp Reserves, comprising 19 square miles have not yet been demarcated.

During the nine years since the appointment of a Forest Officer, 266 miles of reserved forest having a total of 452 miles of boundary lines have been demarcated. The marks used to define the boundaries consist of cuttings of Dracena or 'Rayos' at frequent intervals along the boundary lines, of concrete blocks or monuments, about 6 inches square and 18 to 24 inches long, of which 12 to 15 inches is under ground marked 

together with serial numbers or bottles or stones set in the ground at

angles in the boundary lines, and in addition, of trees blazed and stamped (E.R 19) and enamelled iron sign plates bearing the inscription 'Government Reserved Forest', fixed to trees adjacent to the actual lines. The boundary traces are cleared at intervals to a width of 10 feet, to render the boundaries clearly visible.

Plantation Work.

In forests like these of Trinidad and Tobago, where as a rule, only 5 to 10 per cent. of the species of trees are marketable, the improvement of the forest reserves, in order to render them in a higher degree revenue-producing, is a matter of great importance.

This question was given careful consideration while demarcation was proceeding. The species in greatest demand, both for local use and for export, were studied, and the localities best adapted to their successful growth, noted. The following is a short account of the principal trees in common use in Trinidad and Tobago.

CEDAR—(*Cedrela odorata*). A large tree known in Europe as West Indian Cedar, 60 to 80 feet high, 4 to 6 feet in diameter: wood of a red or brown colour; splits easily; soft and porous; has a strong scent, and for this reason is much used for wardrobes and such articles of furniture; weighs about 36 lb. per cubic foot; crushing strength 2·94 tons per square inch. It is much used for boards, shingles, furniture and framing, and is exported to Europe for making cigar boxes. It grows singly or in small groups, preferring good soil.

BALATA or BULLET WOOD—(*Mimusops globosa*, Gaertn.). A large tree 80 to 100 feet high, 4 to 6 feet in diameter; wood dark-red, dense, heavy, hard, very durable; weighs 70 lb. per cubic foot; crushing strength 4·77 tons per square inch. It is eminently suitable for posts, bridges and all kinds of outdoor work, and is much used by wheelwrights. Value £10 per ton. Grows singly or in small groups, preferring ridges or sloping ground; not particular as to soil. The supply of this tree has been much reduced by tapping or bleeding for its gum, which is intermediate in character between rubber and gutta-percha.

POUI—(*Tecoma serratifolia*, Don.). A tree 30 to 50 feet high, 1½ to 2½ feet in diameter, wood grey or green, hard, heavy, very durable; weighs about 70 lb. per cubic foot. It is the best wood in the Colony for posts and all kinds of outdoor work, and grows in a mixed forest, forming only a small proportion of the growing stock. Value £10 per ton.

LOCUST—(*Hymenoea Courbaril*, L.). A large tree 60 to 80 feet high, 2 to 4 feet in diameter; wood of a reddish-brown colour, streaked, close-grained, hard and tough; weighs 69 lb. per cubic foot; crushing strength 5·17 tons per square inch: it will not last in the ground, but is suitable for cabinet work and furniture. Value £10 a ton.

PURPLE HEART—(*Peltogoyne purphyrocardia*, Gr.). A large tree 50 to 80 feet high, 1½ to 3 feet in diameter; wood of a dark

purple colour, hard, heavy, close-grained tough and durable: suitable for furniture, cabinet work, and buildings, but somewhat difficult to work.

CRAPPO or CARAPA—(*Carapa guianensis*, Aubl.). A tree 40 to 60 feet high, 1½ to 3 feet in diameter; wood reddish in colour, liable to warp if used unseasoned; weight 42 lb. per cubic foot, durable, easily worked, and suitable for building, is plentiful in mixed forests. Value £8 per ton.

BLACK OLIVIER—(*Terminalia Buieras*, L.). A tree 40 to 60 feet high, 2 to 3 feet in diameter; durable, especially in water or damp situations; used for boards, planks, posts and shingles, etc.; suitable for all outdoor work; grows quickly and is fairly common.

RED MORA—(*Mora excelsa*, Benth.). A large tree 80 to 120 feet high; 2 to 4 feet in diameter; wood a chestnut-brown colour, hard, heavy, tough, strong, close-grained, very durable in water or damp situations; weight about 65 lb. per cubic foot; suitable for boards, scantlings, and especially for large beams; is one of the first-class woods at Lloyds; grows gregariously on low-lying land subject to inundations and does well on poor soil, especially when this is sandy.

ACOMA—(*Sideroxylon mastichodendron*, Jacq.). A large tree 50 to 80 feet high, 2 to 3 feet in diameter; wood chestnut or brown in colour, dense, hard, heavy, durable; weighs 66 lb. per cubic foot; used for posts and frames of buildings, and for outdoor work.

WATERCAIRE OR AQUATAPANA—(*Lecythis laevifolia*, Gr.). A large tree 60 to 80 feet high, 2 to 3 feet in diameter; wood durable, used for posts and outdoor work, and for temporary bridges; value £8 per ton.

CYP—(*Cordia gerascanthus*, Jacq.). A tree 40 to 50 feet high, 2 to 3 feet in diameter; wood light-brown, of medium hardness, tough, easily worked: weight 38 lb. per cubic foot; used for joinery, furniture and cabinet work, and carriage building.

BALSAM—(*Copaifera officinalis*, Jacq.). A large tree 40 to 60 feet high, 2 to 3 feet in diameter; wood dark-brown, finely marked, used for shingles, staves, and repairs to railway carriages; suitable for furniture and cabinet work; easily worked, rather scarce.

ROBLE—(*Platymiscium platystachium*, Benth.). A tree 30 to 40 feet high, 1½ to 2 feet in diameter; wood reddish-brown, hard and durable; suitable for outdoor work, cabinet work and furniture.

FUSTIC—(*Maclura tinctoria*, L.). A small tree 20 to 40 feet high, 1 to 2 feet in diameter; weight about 44 lb. per square foot; is used by wheelwrights, and yields a yellow dye for which it is exported occasionally, value £3 to £5 per ton.

It should be stated that the measurements of diameter recorded above were made at a height of 5 feet from the ground.

Though it was realized that improvement fellings would probably in the end yield better results for the expenditure incurred than the establishment of plantations, certain circumstances favoured the adoption of the latter method of increasing the value of the Forest Reserves.

It will be readily understood that, while demarcation was being actively pushed on, and resources were limited, it was impossible to give much attention to plantation work, that improvement fellings had to be left to a later date, and that the preparation of 'working plans' for the reserves was altogether out of the question.

In fact, it was not until 1908 that plantation work, even on the smallest scale, could be attempted. In that year it was decided to devote a small portion of available funds to plantation work, at the cost of a somewhat reduced rate of demarcation. An area was therefore selected in the cedar forests, within the Southern Watershed Reserve, about $1\frac{1}{2}$ miles from the south coast of Trinidad, for a cedar plantation. Ten acres of forest containing two cedar trees and three stumps of previously worked trees were felled and lined out 20 feet × 10 feet. The area was not burned as it usually is in preparing land for planting cacao. The rows were laid out north and south at right angles to the prevailing wind and a few small trees such as could subsequently be removed without injury to the young crop were left as temporary shade. As no forest nursery existed, and the cost of transport of plants from the Botanical Gardens in Port-of-Spain (40 miles by rail, 15 by road and 6 by foot-track) was prohibitive, it was only found possible to plant 5 acres with seedlings collected from the adjoining forest during the year 1907-8. In the following July, cedar seeds obtained from a selected tree were sown. In each subsequent year a further 10-acre block has been felled and planted with cedar. Seeds were sown at pickets in June and July, transplants being used as supplies later on as required. Some damage has been done to the young cedar by a twig borer that destroys the leading shoots, causing some loss of growth. Fortunately, natural enemies are keeping this pest in check. In addition to the cedar plantation, an area of $25\frac{3}{4}$ acres in the Arima Reserve in the lower slopes of the Northern Range have been planted with Cyp (*Cordia gerascanthus*, Jacq.), West Indian Mahogany (*Swietenia macrophylla*), and a few *Hevea brasiliensis*. This plantation was started in 1908 with 250 Cyp and 150 West Indian mahogany on $1\frac{3}{4}$ acres, to which was added 2 acres in Cyp and Honduras mahogany, as well as 22 acres in Cyp with a few plants of *Hevea brasiliensis* in 1910-11, the latter area having been treated to a seeding felling in the previous year.

In the Central Range Reserve, too, 20 acres of forest, containing nothing of value, was felled and lined out 20 feet × 10 feet, in 1910-11. Of this 6·3 acres was planted with a mixture in groups, of Poui, *Hevea brasiliensis*, and Honduras mahogany, the remaining 13·7 acres being sown with Cyp, after the close of the financial year.

The total area of plantations at the end of the year 1910-11 stood at $85\frac{1}{2}$ acres and contained

8,720	Cedar
5,065	Cyp
502	Poui
738	Honduras mahogany
440	Hevea brasiliensis
175	West Indian mahogany
Total 15,640	

A further 50 acres is being planted, in 1911-12, principally with Cyp and Cedar.

No plantation work has as yet been found possible in Tobago.

The following estimate of the cost of forming a cedar plantation of 100 acres on the lines above recorded, and the probable financial results, may be of interest. The prices are fixed with regard to the wages current in Trinidad, where estate labour costs 40 c. (1*s.* 8*d.*) a day, and forest labour, where the men have to sleep away from their homes, costs 60 c. (2*s.* 6*d.*) a day.

ESTIMATE FOR A CEDAR PLANTATION OF 100 ACRES.

EXPENDITURE.

			$ c.
Felling 100 acres at	$6·25	per acre	625·00
Burning and fire traces	$1·50	,,	150·00
Stacking and burning logs	$5·00	,,	500·00
Preparing pickets	$1·00	,,	100·00
Lining out with pickets	$2·25	,,	225·00
Preparing planting holes	$6·00	,,	600·00
Sowing, ...	$2·00	,,	200·00
Nursery for supplies ...			600·00
Total, first year			3,000 00

	$ c.
2nd year, cleaning and supplying	1,000·00
3rd year, ,, ,, ,,	900·00
4th year, ,, ,, ,,	700·00
5th year, cleaning	500·00
6th year, ,,	350·00
7th year, ,,	300 00
8th, 9th & 10th years, cleaning, at $1·50 p.a.	450·00
Total 2nd to 10th year	4,200·00
11th to 60th years maintenance at 48 c. per acre per annum	2,400·00
Grand Total	9,600·00

RECEIPTS.

Sale of thinnings in 30th to 40th year 8,000 trees at $2·00 per tree	$16,000·00
Final crop in 60th year, 10,000 trees at $5·00	50,000·00
	$66,000·00
Profit	$56,400·00

NOTE.—As 21,600 trees would be planted, the above estimate allows for a loss of 3,600 from various causes.

PAPERS NOT INCLUDED IN THE FOREGOING SECTIONS.

A METHOD OF ESTIMATING CALCIUM CARBONATE IN SOILS.

BY HERBERT S. SHREWSBURY, F.I.C.,

Assistant Government Analyst, Trinidad.

This method was devised as an alternative to processes depending on the measurement of carbon dioxide evolved from the carbonates in the soil, by absorption or otherwise. These processes have not been found very satisfactory. The modified method proposed by F. S. Marr (*Journal of Agricultural Science*, 1909, iii, p. 155) appears to give good results, but is somewhat lengthy and entails rather special apparatus and skilful manipulation for its successful application.

The following method depends upon the extraction of the calcium carbonate from the soil in quarter-normal acetic acid, the conversion of the calcium acetate so formed into calcium oxide, and its solution in deci-normal acetic acid, and the titration of the excess of acid required by the lime with deci-normal potash or soda using phenolphthalein as indicator.

The Process.

Ten grammes of finely divided air-dried soil are placed in a dry wide-mouthed flask or bottle and 100 c.c. of roughly quarter-normal acetic acid are added.

During ten minutes the flask is shaken with a rotary movement every time the bulk of the soil settles, which occurs approximately every thirty seconds.

The soil is then allowed to settle for the last time, and the liquid contents of the flask decanted through a dry filter. Schleicher & Schüll's filter hats answer the purpose admirably.

A control experiment is made with another 10 grammes of soil, using distilled water as the extracting solvent.

Twenty-five cubic centimetres of each filtrate is evaporated to dryness in a platinum dish and ignited at a bright red heat for thirty minutes.

The residues when cool are treated with 10 c.c. of deci-normal acetic acid (or more if necessary).

Solution is effected in a few minutes, particularly if the residues are gently rubbed with a glass rod tipped with a small rubber bung.

The excess of acid is then titrated with deci-normal soda or potash and phenolphthalein used as indicator.

The volume obtained from the control is now subtracted from that obtained from the acid extraction of the soil and the result multiplied by 0·2. The product gives the percentage of calcium carbonate in the soil.

NOTES ON THE PROCESS.

The quantities given will answer for soils containing up to 5 per cent. of calcium carbonate, which covers the usual range For larger percentages, proportionate amounts of soil are taken.

The time and method of extraction were based on experiments made with pure calcium carbonate and quarter-normal acetic acid.

Some soils appear to retain a portion of the calcium acetate presumably by reason of a greater concentration of the solution occurring in immediate contact with the soil particles. The occasional error due to a soil of this type does not appear to be large enough to warrant a complete washing of the soil, an operation which is lengthy and tedious.

The purpose of the control is to measure carbonates of the alkalis, organic salts of the alkalis, soluble organic calcium salts, calcium nitrate or any bodies which are soluble in water and which on ignition leave an alkaline residue soluble in deci-normal acetic acid.

One-tenth of a cubic centimetre of deci-normal acid was the maximum obtained in this titration for three soils that were examined.

Deci-normal acetic acid is chosen for the solution of the residues because it does not dissolve ignited iron oxide, whilst easily attacking calcium oxide.

It appears better to measure the calcium oxide by titration than to weigh it or estimate it by conversion into oxalates and comparison of the turbid liquid with standards, since the first method excludes other salts of calcium than the carbonate, with the possible exception of organic calcium salts insoluble in water but soluble in quarter-normal acetic acid.

It is desirable to make qualitative tests on the same volumes of the acetic acid extract of the soil for the presence

of calcium and magnesium chlorides and sulphates. Frequently the last three are only present in traces.

If the amount of magnesium is comparatively large, it may be quickly estimated, if desired, by the method given by Thresh (*Examination of Water and Water-Supplies*, p. 238) depending on the comparison of the precipitate obtained with sodium hydrogen phosphate (after removal of calcium with ammonium hydrate and ammonium oxalate) when shaken up in a certain volume of water, with standards prepared in the same way.

The magnesium estimated would of course include any salt of magnesium soluble in quarter-normal acetic acid, but in most soils the error introduced would be insignificant.

TEST EXPERIMENTS.

The following table sets out the results of test experiments, made with the process on soils prepared with known percentages of calcium carbonate. The sample of precipitated chalk used for this purpose was analysed and found to contain practically 100 per cent. of calcium carbonate.

Sample of soil.	Percentage of calcium carbonate in soil.			
	Originally present.	Added.	Total.	Found by process.
A. Surface soil from soft ferruginous shale	0·07	0·65	9·12	0·13
B. Heavy clay subsoil previously treated with hot concentrated hydrochloric acid for twelve hours, washed and dried in steam oven	Nil	0·50	0·50	0·50
C. Clay subsoil	0·29	0·50	0·79	0·61
D. Clay subsoil	0·23	4·76	4·99	4·86

MILKING CAPACITIES OF THE TRINIDAD GOVERNMENT FARM COWS.

By HERBERT S. SHREWSBURY, F.I.C.,
Assistant Government Analyst.

An investigation has been made (with the co-operation of Mr. J. McInroy, manager of the Trinidad Government Farm and St. Augustine estate) of milk yielded by the cows on the Trinidad Government Farm. The yield given by each animal was measured and a fair sample of its milk sent to the laboratory in order that its quality might be valued by analysis.

The results obtained up to date are tabulated, below, according to breed.

HALF-BRED ZEBU.

Number of cow.	Yield in quarts.	Total solids, per cent.	Solids not fat, per cent.	Fat, per cent.
1	4	14·33	8·13	6·20
2	10	14·14	8·94	5·20
3	4	14·12	8·62	5·50
4	6	13·65	8·65	5·00
5	7	13·33	9·53	3·80
6	5	13·24	8·89	4·35
7	5	13·22	9·62	3·60
8	9	13·18	8·78	4·40
9	6	13·10	9·60	3·50
10	8	12·83	8·93	3·90
11	4	12·71	9·11	3·60
12	5	12·70	8·90	3·80
13	10	12·70	8·90	3·80
14	4	12·70	8·70	4·00
15	6	12·60	9·30	3·30
16	4	12·60	9·00	3·60
17	4	12·58	8·68	3·90

HALF-BRED ZEBU.—(*concluded.*)

Number of cow.	Yield in quarts.	Total solids. per cent.	Solids not fat, per cent.	Fat.
18	4	12·46	8·56	3·90
19	5	12·45	8·45	4·00
20	5	12·34	8·74	3·60
21	7	12·28	9·88	2·40
22	9	12·12	9·02	3·10
23	5	12·06	9·01	3·05
24	6	12·00	9·00	3·00
25	4	12·00	9·00	3·00
26	7	11·87	8·87	3·00
27	4	11·85	8·55	3·30
28	5	11·84	8·14	3·70
29	4	11·82	8·97	2·85
30	7	11·79	9·69	2·10
31	5	11·77	9·27	2·50
32	4	11·65	9·15	2·50
33	5	11·40	8·90	2·50
34	4	11·38	8·68	2·70
35	7	11·19	8·24	2·95
36	6	11·17	9·17	2·00
37	5	11·16	8·86	2·30
38	5	11·06	9·26	1·80
39	6	10·31	8·51	1·80
40	4	10·20	8·65	1·55
Average	5·6	12·29	8·92	3·37

HALF-BRED RED POLL.

Number of cow.	Yield in quarts.	Total solids, per cent.	Solids not fat, per cent.	Fat, per cent.
1	4	14·25	8·75	5·50
2	9	13·54	8·94	4·60
3	6	13·52	8·72	4·80
4	4	13·51	8·41	5·10
5	4	13·42	8·82	4·60
6	6	13·26	10·46	2·80
7	5	12·82	8·82	4·00
8	6	12·70	8·70	4·00
9	5	12·70	8·90	3·80
10	5	12·70	8·70	4·00
11	4	12·49	9·19	3·30
12	4	11·39	8·69	2·70
13	5	11·03	8·73	2·30
Average	5·1	12·87	8·91	3·96

Considering this table in the same way, the half-bred Red Polls give the following results :—

These cows may be classed as follows, according to the quality of their milk :—

Fats of 3·5 or more (very good)		50 per cent.
„ 3·0 and upwards but less than 3·5 (good)		17·5 „
„ 2·0 „ „	3·0 (poor)	25·0 „
„ less than 2·0	(very poor)	7·5 „

With regard to quantity of milk, 40 per cent. of the cows yield more than 5 quarts and may be classed as ' very good'.

The 40 per cent. of cows giving very good quantities of milk may be again classed, as below, with regard to the quality of milk given :

Very good	17·5
Good	10·0
Poor	10·0
Very poor	2·5
	40·0

The milk from No. 21 is of abnormal character. Nos. 2, 4, 5, 8. 10. 9 and 13 are excellent cows, giving large yields of first-class quality milk, whilst Nos. 15. 22. 24 and 26 are very good cows yielding large quantities of milk of fair quality.

Quality of the milk.

Very good	... ...	69 per cent.
Good	... ...	8 „
Poor	... ...	23 „
Very poor	... ...	nil

Quantity of milk.

Very good, 31 per cent. Consisting of 23 per cent. also very good in quality, and 8 per cent. poor in quality.

Nos. 2, 3 and 8 are thus excellent cows, both in yield of milk and the quality of milk given.

The remaining cows, with the exception of No. 6, which gives abnormal milk, and of Nos. 12 and 13, give milk of good quality, but are rather deficient in the quantity they yield.

HALF-BRED GUERNSEYS.

Number of cow.	Yield in quarts.	Total solids, per cent.	Solids not fat, per cent.	Fat, per cent.
1	5	13·30	8·90	4·40
2	6	12·58	8·58	4·00
3	8	11·94	9·19	2·75
4	5	11·82	8·97	2·85
5	8	11·62	8·62	3·00
6	7	11·40	9·00	2·40
7	7	11·29	9·09	2·20
8	8	10·61	8·56	2·05
Average	6·8	11·95	8·99	2·96

GUERNSEY.

	5	13·18	8·98	4·20

Proceeding as before, we have—

Quality of milk.

Very good	25 per cent.
Good	12½ „
Poor	62½ „
Very poor	nil

Quantity of milk.

Per cent. cows 'very good' 75, composed of:—

„	Very good	12½ per cent.
„	Good	12½ „
„	Poor	50 „
„	Very poor	nil

No. 2 is excellent in quantity and quality of milk. No. 1 gives excellent quality of milk, but the yield is somewhat below the average.

Nos. 3, 5, 6, 7 and 8 give good yields of poor quality milk.

No. 4 is poor both in quality and quantity.

It is of interest to compare the pure-bred Guernsey with the two half-bred Guernseys heading the table. Whilst giving no greater yield than No. 1, the Guernsey's milk is somewhat poorer in quality, whilst No. 2, though giving somewhat poorer quality than the Guernsey, supplies a better yield.

It should be pointed out, however, that the Guernsey is a young cow, and may be expected to yield larger quantities of better quality milk later on.

HALF-BRED SHORTHORN.

Number of cow.	Yield in quarts.	Total solids, per cent.	Solids not fat, per cent.	Fat, per cent.
1	7	12·48	9·08	3·40
2	6	12·35	8·85	3·50
Average	6 5	12·41	8·96	3·45

Both these cows are very good in the quality and quantity of milk they yield.

HOLSTEIN BREED.

Number of cow.	Yield in quarts.	Total solids, per cent.	Solids not fat, per cent.	Fat, per cent.
1	4	12·08	8·18	3·90
1	4	11·85	8·35	3·50
Average	4	11·96	8·26	3 70

This cow yields a good quality milk, though the solids not at are distinctly low. In spite of the fact that the quantity of milk given is poor, since the cow is only four years old, she may be expected to improve in this respect.

Breed.	Average yield in quarts.	Composition of average milk.			Cows 'very good' in quantity of yield, per cent.	Cows yielding 'very good' quantity giving milk of quality:			
		Total solids, per cent.	Solids not fat, per cent.	Fat, per cent.		Very good.	Good.	Poor.	Very poor.
Half-bred Zebu ...	5·6	12 29	8·92	3·37	40	17½	10	10	2½
Half-bred Red Poll ..	5·1	12·87	8·91	3·96	31	23	..	8	...
Half-bred Guernsey	6·8	11·95	8·99	2·96	75	12½	12½	50	..
Guernsey	5	13·18	8·98	4·20	...	...	...	...	...
Half-bred Short-Horn	6·5	12·41	8·96	3·45	...	...	...	...	...
Holstein	4	11·96	8·26	3·70	...	...	...	...	...

It is obvious that this comparison must not be pressed too far, as the number of half-bred Red Polls and half-bred Guernseys examined was very much smaller than the number of half-bred Zebus. As far as the comparison goes, however, the half-bred Zebu seems to be the best breed, as regards quality and quantity of milk yielded: the 27½ per cent. of cows giving 'good' and 'very good' milk both in quality and quantity compared favourably with the figures 23 and 25 for half-bred Red Polls and half-bred Guernseys, respectively.

Amongst the half-bred Zebus, we have cows giving the best quality of milk and also the largest yields of 'very good' quality milk. Unfortunately they also supply the cows giving the poorest yields and poorest quality of milk. There appears a possibility, however, of producing very fine milking animals by selection from this breed.

THE PROFITABLE BREEDING OF HORSES.

BY J. L. SHANNON, D. V. M.,
Barbados.

It might be well to mention at the outset that the object sought in presenting this paper is not the enunciation of any original theories on the breeding of horses, but rather the commending most earnestly to West Indian horse breeders, the American carriage horse which is being developed jointly by the United States Department of Agriculture, and the Experiment Station at Fort Collins, Colorado, an account of which appears in the twenty-fourth Annual Report of the Bureau of Animal Industry of the United States Department of Agriculture for the year 1907. It is hardly necessary to draw the attention of stock raisers in the West Indies, to the wisdom of profiting by the results of the experiments in animal breeding and feeding undertaken by the United States Government in co-operation with the various State Agricultural Experiment Stations.

The annual appropriation which has made possible the development of the strain of carriage horses which it is the purpose of this paper to prove to be the most profitable type to breed in the West Indies, has been $50,000 since July 1, 1907.

A cause justifying the expenditure of so large a sum of money annually, should certainly not be considered unworthy of the attention of our stock raisers.

THE AMERICAN CARRIAGE HORSE ADVOCATED.

The reasons for advocating the breeding of American carriage horses are precisely the same as those given by George M.

Rommel, Animal Husbandman, of the United States Bureau of Animal Industry, for taking up of their breeding by the United States Government; and since it is one of the objects of this paper to advocate the supplying of the New York market with carriage horses bred in the West Indies, the same reasons apply, namely:

'That carriage horses are as a rule the most valuable class on the market: that as a result of the strong demand the supply was gradually diminishing, and that notwithstanding all the importations of the carriage type from abroad, the preferred horse was the American horse.'

HISTORY OF THE BREED.

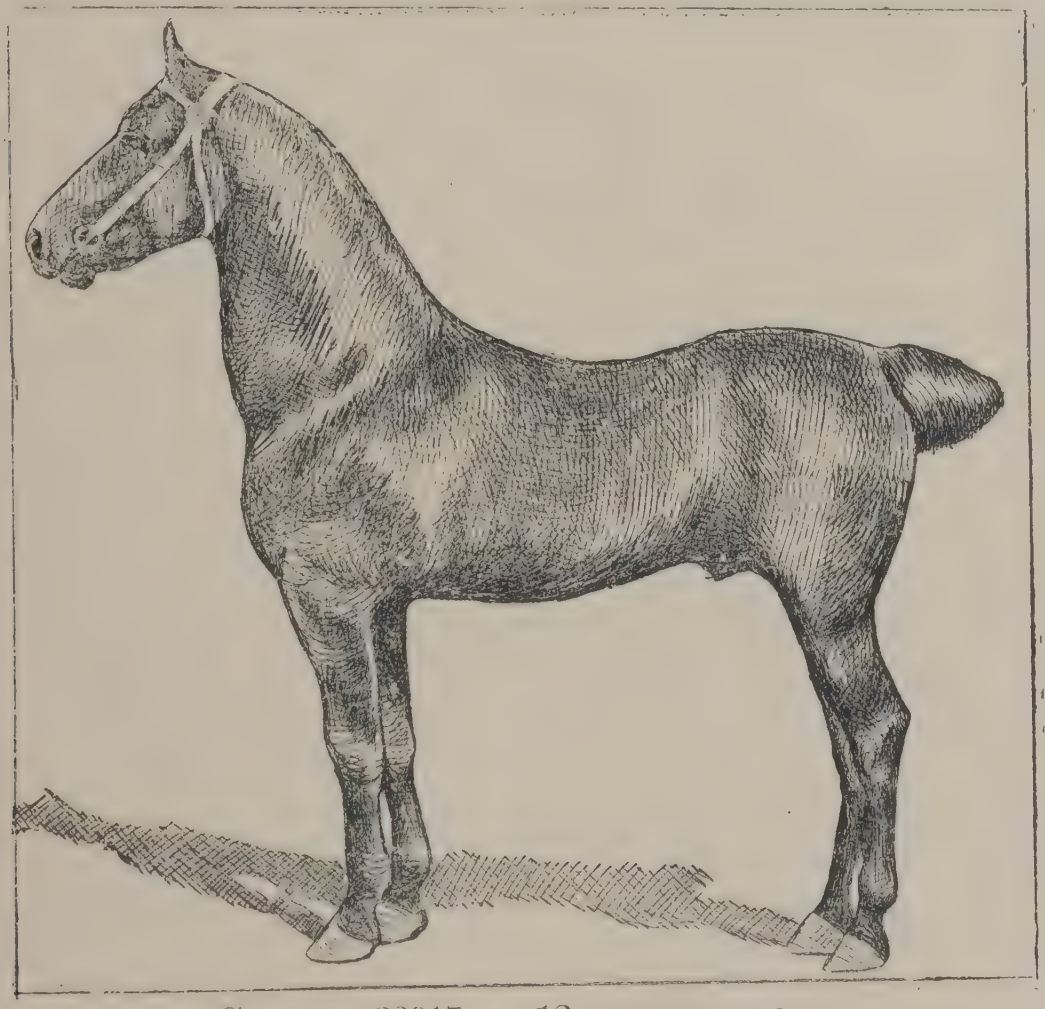
The horses appearing in the coach or heavy harness classes of the American show-rings for a number of years, were almost all imported, the majority being Hackneys, French and German coach-horses. A few Cleveland Bays and Yorkshire Coachers were also exhibited. Shrewd American horsemen observed that occasionally 'sports' or 'freaks' occurred amongst the breeds known as the American Kentucky Saddle horse and the American Standard-bred trotter. The freaks from the latter breed not being possessed of the extreme speed of their parents, owing to their coach-horse action and conformation, were valueless to the breeders of trotting race-horses. And so it came about that these freak coach-horses found their way into the show-ring in competition with the imported breed, first masquerading under the name of the foreign breed, but finally standing on their merits as American horses. The pedigrees of these horses were traced by intelligent breeders, and since they were possessed of superior endurance and speed to that of the Hackney, with equally perfect action, it was thought advisable to test the prepotency of these 'sports' with the object of fixing the type and thus originating a new breed. The results obtained at Fort Collins, Colorado, in these experiments, go to prove the correctness of Mr. Rommel's statement that, in view of the fact that the foundation stock used at Fort Collins was the best blood for the production of carriage-horses that could be obtained in Kentucky at the time (as proved by a study of the pedigrees of native-bred horses of the coach type), the addition of such stock to the stud was an experiment, only in so for as any mating was an experiment.

The ability of these standard-bred coach-horses to hold their own against the imported breeds in style, action and beauty of conformation, besides being possessed of superior endurance and speed, was clearly demonstrated by Mr. Thomas Lawson, of Boston, several years ago, who collected and exhibited in the leading show-rings of America, his famous 'Glorious Four,'; so named because of the use of the prefix 'Glorious' to names of each of the four stallions which he exhibited most successfully, separately, and as a four-in-hand team. One of these stallions 'Glorious Thunder Cloud', registered in the American Standard-bred Registry, as Carmon No. 32917, and now known by the latter name, is at the head of the Government stud at Fort Collins. This animal is the subject of the illustration

used in this article, to give as good an idea as can be obtained from a photograph, of the type of the American carriage horse. At the leading shows separate classes for the American carriage horse are now provided.

SUGGESTIONS.

The advantages of using sires of the American carriage-horse breed, on the class of brood mares employed in Jamaica and many of the other West India islands, should be readily appreciated by those familiar with the correct type of horse for carriage purposes. If there is any profit in raising, for carriage purposes, the animals so deficient in all of the characteristics of the carriage horse, as is the case with the animals usually of thoroughbred ancestry raised in the West



CARMON, 32917, AT 12 YEARS OF AGE.

Standard carriage stallion shown as 'Glorious Thunder cloud', at the head of the Government stud at the Colorado Experiment Station since 1905.

Indies, would it not be far more profitable to breed horses which could be placed on the New York Market at the price that is usually obtained for the one race-horse out of every hundred produced by the present system of using only thoroughbred stallions which are selected for their ability to run regardless of anything else?

The following statement appearing in the Twenty-fourth Annual Report of the United States Bureau of Animal Industry

is of particular interest in this connection: 'In Kentucky, the breeding of horses for individual excellence of conformation, quality and action is carried to a greater degree than in any other State, and, contrary to popular opinion, the most of the men outside of the thoroughbred establishments, who make their living from horse breeding in Kentucky, in the blue grass counties at least, are breeding not for speed but for type. This has been going on for years, and for this reason the good handsome horses of Kentucky have usually been appreciated, their history traced, and their descendents accounted for.' American statistics show that the breeder of standard-bred race horses has only about one chance in nine of getting a horse that even approaches being a profitable investment, unless he has in mind some other breeding standard than speed. Turning to English authorities, we find Admiral Rouse credited with the statement that there is an average of about three remarkable runners in 2,000.

In breeding carriage-horses for the New York market, the local demand would be supplied by those few coach-horses which lacked the desired height of action for the American market, and these misfits would possess superior conformation and endurance to anything bred or imported into the West Indies at the present time; the deficiency in height of action would rather enhance the value of the few misfits, in the home market, being in accordance with local taste and demand.

Co-operation between the Imperial Department of Agriculture for the West Indies and the various Government stock farms throughout the West Indies in the carrying out of such a scheme should work wonders in the improvement of our horses within a few years. In addition to the sires kept at the stock farms, a few mares of pure breed should also be added to the stud. The expert, directing the breeding, would exchange sires between the islands when necessary, and, by judicious selection and proper mating of the pure-bred young at the various stock farms, far more profitable results would be obtained almost in as many years as it has taken centuries to produce the nondescript lot of horses at present to be seen in the West Indies. The present aimless system adopted at the Government stock farms, of using a hackney sire, and at his death returning to the thoroughbred, then standard-bred, and back to the thoroughbred again, is the system which characterizes unprogressive farmers in certain sections of the United States. Those sections that have adopted the co-operative system of breeding by adhering to a single breed and exchanging sires among themselves, have made stock raising a profitable industry, while the former class have made an absolute failure of it.

The importation of thoroughbred stallions, which are inferior as racers to those owned by private individuals, relegates them to the production of carriage-horses for which purpose the racing strain of thoroughbred is entirely unsuited.

Yet the American carriage-horse is practically thoroughbred, since his ancestors on both sides of his pedigree trace to thoroughbred sires. The American saddle-horse is descended from the thoroughbred stallion Denmark, an animal which was possessed of beautiful conformation which he had the power to

transmit to his off-spring. The thoroughbred stallion Messenger was the originator of the standard-bred trotter. Many of his progeny, which are out of American mares, showed speed at the trot for which they were developed by selection.

The breeding of race-horses should be left to private individuals of means, and Government aid should be given only to the production of the best type of carriage-horse, namely, the American carriage-horse which has been produced by the scientific stock breeder. The type selected should receive undivided attention over a series of years, for only by such a method can improvement be effected in any breed of live stock. Indiscriminate crossing of breeds nearly always leads to failure.

[Pages 219 to 291, issued July 23, 1913.]

THE WINDWARD AND LEEWARD ISLANDS CONSIDERED IN RELATION TO FORESTRY.

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Imperial Commissioner of Agriculture for the West Indies.

Introductory.

The importance of the preservation of adequate forest areas, especially in mountainous islands situated in the Tropics, has, for sometime, been generally recognized; but now that such areas are steadily diminishing as the demand for agricultural land increases, the subject is receiving very definite attention.

Whilst forests have many direct uses in that they supply timber and sundry minor products, it is in regard to their indirect effects that they are chiefly important in those islands at present under consideration.

The indirect effects of forests mainly have relation to rain and moisture, and are largely the outcome of the retarding influence exercised by the trees on the flow of water that has been precipitated. On areas bare of trees, particularly where these exist on mountain or hillsides, water, falling as rain, flows away immediately, forming swollen torrents whose beds tend to become dry soon after the rain ceases. In passing over unprotected land, the water, in its rapid movement, carries away loose soil—a fact rendered evident by the turbidity of mountain streams arising under such conditions. Hence the unclothed hillsides tend to revert to bare rocks incapable of supporting even the growth of trees, and consequently become of no value at all for purposes of cultivation.

The streams, themselves, arising under such conditions, are extremely irregular in their flow: torrential while rain lasts, and failing soon after the downpour ceases. Such water-courses are a source of danger during their brief period of flow, because they are liable to cause much damage through cutting away land lying along the lower part of their courses: a source of inconvenience in that by piling sand, gravel and stones over roads, drains or cultivated areas, they give rise to considerable injury and expense. Streams of this character are of little value even as a source of water-supply.

When, however, rain falls on a forest-clad area, very different results ensue. From the nature of the forest bed with its covering of leaves and its abundant roots of trees, the falling water is distributed and retained for a considerable time, so that even when heavy rain falls on a forest area, the water escapes slowly; consequently the resulting streams are equalized, being retarded in their coming into flood, and slow in subsiding. Thus they are much less liable to inflict damage on the lands lying along their lower reaches. Such streams seldom fail entirely, hence they are valued as sources of water-supply. From the more equable and diffused manner in which the water flows over the gathering ground, soil erosion is greatly reduced, made evident by the fact that streams arising from forest areas are frequently clear and free from sediment even when in flood.

Whilst exercising this beneficial effect on the immediate streams arising near the forest area, it is evident that the influence is extended to the springs which slowly deliver the water retained for a considerable time by the forest bed; these springs may make their appearance immediately on the margin of the forest area, or they may be situated a considerable distance away, the water being slowly conveyed to them either through porous rock or through fissures. In addition to this, it is being increasingly recognized that much of the water retained by the forest bed may slowly percolate in a diffused manner through the surrounding soil, and may serve to maintain a useful degree of moisture in the subsoil of land lying at a considerable distance away. This subsoil moisture thus steadily maintained by the distant forest may greatly increase the fertility and drought-resisting power of cultivated lands, and it is conceivable that in many of the islands under consideration, the cultivated lands at the foot of the mountains may derive considerable benefit from the retentive forest bed on the mountain tops situated a long way off.

It is to this retention and slow distribution of the water falling as rain, that forests owe their chief benefits: by conserving the water, delivering it equably, and by rendering it available, practically continuously, forests are of fundamental importance in mountainous islands. The question constantly arises whether forests appreciably increase the actual rainfall. It is most difficult to give a satisfactory answer supported by well ascertained facts. The probability is, however, that forests, by lowering and equalizing the temperature of the air on mountain tops, may to a small extent lead to

increased precipitation: this increase, however, is probably almost negligibly small when compared with the benefits derived from forests as regards conservation.

It would appear evident that trees have a marked effect in reducing the temperature of the air and of the ground in the covered area, and this lowering of temperature may beneficially affect places situated some distance beyond the forest: at the same time dew-formation is promoted; there is thus created a humid atmosphere around the forest, which, in tropical countries, is gratefully acceptable.

The mechanical effects of forests and timber belts in controlling air currents are facts of much importance in agriculture. It is recognized that the effect of strong or continuous wind currents are prejudicial to many forms of tropical crops, and this fact has to be taken into serious consideration, particularly in laying out land for orchard cultivations. Retention of areas in forest, or the planting of trees as wind-breaks must be regarded as matters of ordinary agricultural practice.

In what follows, an endeavour is made to describe in brief outline, the condition of each island of the groups under consideration in so far as their forests are concerned. An attempt is made, also, to record the nature of the enactments or regulations having a bearing on questions pertaining to reforestation, preservation and similar matters connected with sylviculture in general.

Grenada.

The wooded areas of Grenada are principally confined to the higher portion of the range of hills traversing the island from north to south: this range is situated nearer to the western than to the eastern side of the island; numerous spurs run from this range: these are more pronounced on the western side; on the eastern, there are wider spaces of open valleys capable of cultivation even over the intervening ridges.

As cacao constitutes the principal crop of the island, the valleys and hillsides of a very considerable portion of the country are covered with tree-growths so that there is not much evidence of denudation.

The actual areas covered by trees that may be regarded as constituting anything in the nature of a forest are to be found on Crown Lands now constituting a Forest Reserve, referred to later, and on some of the highest peaks such as summits of Mount Sinai (2,300 feet), South East Mountain* (2,359 feet) and the numerous peaks around Mount St. Catherine (2,743 feet).

The Colony is in possession of a Forestry Ordinance (No. 13 of 1906) under which there is appointed a Forestry Board, and provisions are made for creating and maintaining 'Rain Reserves' and 'Forest Reserves' under the control of the Board and its officers. A Rain Reserve is any portion of land surrounding the sources or feeders of any spring or river, or any water-supplies in the colony, on which the Board may deem it

* Believed to be Crown Land, but the surveys necessary before it can be added to the Reserve have not yet been made.

desirable to preserve the timber or forest growth. A Forest Reserve is any portion of land which being in a hilly or mountainous district lies above a given altitude or below any prominent mountain ridge or any dividing line of water-shed, and within a stated distance thereof whereon there may be growing timber, or which is the wooded side of a ravine or upon which, in the opinion of the Board, it is desirable to carry out a scheme of reforestation.

Provision is made for the equitable acquirement of private lands when such a course is necessary.

Power is given to the Governor-in-Council to frame regulations to give full force and effect to the general scope and intention of the Ordinance.

To the Forestry Board is entrusted the carrying out of the provisions of the Ordinance. The official members of the Board, assisted by the officers of the Public Works Department, are by the terms of the Ordinance charged with this duty. The Board has power to determine the manner of demarcating the boundaries of Reserves, and of regulating the work carried on within them. Beyond this, the Board has power to make regulations for controlling and limiting the burning of gardens and pastures, and the firing of waste lands, and for the prevention of bush fires. The Board is empowered to prescribe Arbor Days, and to determine the nature of the work to be done in this connexion.

The Ordinance under consideration, which was assented to on July 7, 1906, contained a clause ordering that it shall come into force on such day as the Governor may appoint; it was accordingly brought into force on December 1, 1910.

In order that matters might be put on a perfectly clear footing as regards boundaries, and in order that a well defined and compact block of land should be constituted as a Forest Reserve, a special Act was passed in June 1906 (No. 5 of 1906) authorizing the demarcation of an area of Crown Lands around the lake known as the Grand Etang. and the acquirement of such lands as were privately owned, lying within the line which would constitute a natural boundary for a reserve.

There has subsequently been acquired and added to this Reserve a further area of about 65 acres constituting a part of Clyde estate, situated in St. George's and St. David's parishes.

The Forest Reserve so created comprises some 3 or 4 square miles around the Grand Etang on the hills constituting Mount St. George, Vauclain Mountain, Mount Sinai, and the hills in their vicinity in which several of the principal rivers of the Colony, including the Great River on the east and the Beausejour, Ance Noir and Grand Roy Rivers on the west, take their rise. The work for the past year on and around the Reserve has been restricted to the cleaning of rubber and camphor plantations and boundary lines. The Reserves are not enclosed. There are, however, open traces about 6 feet wide around the Reserve which are kept clean. All corners are worked with iron pipes and the boundaries with dragon's blood.

In most cases, care is taken on the part of estate owners to preserve the timber on the ridges so as to form wind-breaks for the cacao fields, and in order to prevent, to some extent, the denudation of the soil. The trees commonly found are Gourier, Galba, Laurier (4 kinds), Locust, Bais Flot, Maruba, Chautonier, Bois Gris, Penny Piece, Balata, Mustif, Bois Rouge, Bois Bauday, Figuer, Cabbage Palms. As a very considerable area of the Colony is covered with cacao orchards, something approaching forest conditions prevails fairly generally, though it must be recognized that land under cacao cultivation, being to a certain extent cleaned and drained, does not offer the full measure of protection that a regular forest does.

The dangers to be feared in Grenada are the undue denudation of the soil from cleared areas and, where timber has been recklessly removed, the rapid flow of storm water into the streams which in consequence become quickly and dangerously flooded and as rapidly subside.

As already stated, the requirements of cacao cultivation tend to the same ends as forest conservation; the landowners of Grenada have, therefore, definite inducements to follow a line of action which to a large extent offsets the dangers of forest denudation. This, coupled with the existence of the Forest Reserve already created, places the colony in a favourable position in this respect.

The powers given to the Forestry Board under the Ordinance already discussed, appear ample for the needs of the Colony: the Board is in a position to observe continuously the progress of events, and has the powers necessary to take steps to safeguard public interests. It is probable that, in addition to exercising control over the existing Forest Reserves, it may be well to ascertain whether it may not be desirable to take steps at once to ensure the preservation of timber around the head waters of some of the larger streams rising in districts beyond the Forest Reserves and, with the co-operation of the landowners, to ensure the preservation of adequate Rain Reserves as defined by the Ordinance.

St. Vincent.

The island of St. Vincent has a central range of mountains traversing it from north to south: along the western side, the spurs of the hills run down in irregular ridges to the sea, whilst on the eastern side, the ridges are less prominent. Thus the eastern side of the island presents more open country than the western, and of a more undulating character with wider stretches of land capable of cultivation.

At the northern end of the chain lies the Soufrière mountain, having an elevation of 3,623 feet. A mountain path, difficult to traverse, crosses the island over the flank of the Soufrière, and this constitutes the only means of communication from one side of the island to the other; for the rugged central range imposes an effectual barrier. The Soufrière was in active eruption in 1902 when the whole of the forests covering the northern portion of the island were entirely destroyed

The town of Kingstown, with its pleasant harbour, is situated at the southern end of the chain, which divides the island effectually into the windward and leeward districts.

The greater part of the central mountain range, and of the main spurs, is Crown property and is covered with forests. The highlands consist principally of steep hills and precipitous ridges reaching to elevations ranging from 2,500 to 3,500 feet. At present, this district is an effective Forest Reserve, answering adequately the purposes of water conservation. It is very desirable that care should be taken to prevent the destruction of what is undoubtedly a valuable asset to the Colony.

The control of the Crown Lands is regulated by the Crown Lands Ordinance No. 3, of 1906, which gives power to make regulations in respect of: (a) the survey of Crown Boundaries; (b) the management, sale and letting of Crown Lands; (c) the prevention of squatting, encroachment and trespass upon such lands and injury to the woods and forests thereon; (d) the occupation, allotment and survey of such lands; and (e) the issue of grants and fees payable thereon. A section of the Ordinance defines offences in respect to Crown Lands; these include the cutting, destruction or mutilation of trees or the cultivation of land without permission and other acts detrimental to forests interests. This Ordinance, therefore, has the effect of a Forestry Ordinance so far as Crown Lands are concerned, and, provided that reasonable care is taken not to permit the cutting of timber upon land which should properly be retained as a Forest Reserve, or to all of its cultivation, it should adequately protect the situation.

In order to safeguard the position in this respect, an important Proclamation has recently been issued (August 22, 1912), reserving all such Crown Lands in the Colony as are situate 1,000 feet and over, above the sea-level (except such thereof as were prior to such reservation administered or disposed of otherwise so as to prevent or exclude any such reservation) free from any liability to any administration or disposal thereof that would be prejudicial to the conservation of the forests growing thereon.

This is an important step which should have the effect of preserving a considerable area as a forest reserve. It is further to be observed that the Survey Regulations under which Crown Lands are now, and recently have been disposed of, require a reserve for the growth of trees of 33 feet on either side of streams or rivers. This reserve is laid out on the ground at the time the surveys are made and is shown on the plans and grants given to the allottees. It is the duty of the Rangers to prevent allottees from cutting timber and bush on, or cultivating such reserves. It is true that the present legislation in the colony does not make provision, as does that of Grenada, for the acquirement of land for the creation of Forest Reserves. Yet the considerable area of Crown Land now existing in St. Vincent probably renders this power unnecessary, at any rate, at the present stage.

The Colony of St. Vincent is well watered and the rainfall is high. The average precipitation is over 100 inches a year in the neighbourhood of Kingstown, whilst in many other districts the rainfall is heavier. Severe droughts are seldom experienced, and, generally speaking, the condition of the Colony may be regarded as quite favourable from the point of view of rainfall and water-supply. It would appear, therefore necessary to maintain only the reasonable Forest Reserves which exist under the Proclamation of August 22, 1912, made under the Crown Lands Ordinance, for the position of the Colony to be satisfactory in this respect. In view of the fact that arrowroot, which requires for its manufacture large quantities of pure water, is one of the principal industries of St. Vincent, the planters have good and immediate reason for carefully conserving the forests around the watersheds of the streams.

As time goes on it will be well to give attention to the condition of the forests within the reserve in order to ensure that the area remains well covered with timber. The steep character of much of the land falling within the reserved area and the difficulty of access, make it improbable that the definite cultivation and utilization of timber trees will always be a matter of serious concern ; still it is desirable that they should be the object of care, and be periodically reported upon.

A report on the forests of St. Vincent was made in 1886 by Mr. E. D. M. Hooper, of the Indian Forest Service, who describes, in an interesting manner, the condition of the island at that time. He records that ' over a century ago it was feared that the climate was becoming drier from the denudation of the hills from cultivation, and in 1791, a legislative enactment was sanctioned for the protection of the wood on a circular hill on the windward side of St. George's parish near the sea-coast. This hill, known as King's Hill, is about 400 feet high, and was originally reserved for rains by the Commissioners for the sale of lands in 1777, but had subsequently been encroached upon—it was now placed in the hands of surrounding estate-owners, and a heavy fine of £60 was to be levied on anyone cutting or removing timber from it.'

Hooper divides the tree-growths of the island into four main groups : The first or coast flora is notable for its number of White Cedars (*Tecoma leucoxylon*) and Gru-gru palms (*Acrocomia sclerocarpa*), together with Manchineel, Sea-side Grape, Turpentine or Gomea (*Bursera gummifera*), Almond (*Terminalia Catappa*) and Acacias.

The second group comprises the belt above this, ranging from 500 or 1,000 feet up to some 2,000 feet on both sides of the island, where shelter from strong winds is obtainable. This belt contains many valuable timber trees, amongst which are enumerated Angineel (*Andira inermis*), Greenheart (differing from that of Demerara), Locust (*Hymenaea courbaril*), Galba (*Callophyllum Calaba*), Fiddlewood (*Citharexylum* sp.), Pastur or Bastard Fiddlewood (*Nectandra* sp.) Black Cinnamon,

Pimenta acris), Bullet tree (*Mimusops* sp.), Gomea (*Dacroydes hexandra*)—wrongly referred to as *Bursera*—and Ironwood (*Sloanea* sp.).

The third group is the forest flora of the main ridge summit, comprising comparatively few species, none of them attaining any important or useful dimensions. The fourth was that found along the northern coast, between Fancy Owia and Tourama, where existed the ordinary *Bursera gummifera*—a tree known to the Caribs as Mapoo—and Loblolly, and a smooth large-leaved shrub known as Wild Mammee (*Portlandia* sp.). This tract was destroyed by the recent eruptions of the Soufrière.

ST. LUCIA.

St. Lucia is an extremely rugged island having its numerous mountain masses very irregularly disposed. Speaking generally, however, it may be described as possessing an irregular central chain occupying about one-half the length of the island, and from this radiates very numerous, lofty and irregular spurs.

Situated in the central range are Piton Flore (1,850 feet), Morne La Combe (1,485 feet), an unnamed mountain (1,695 feet), Piton St. Esprit (1,996 feet), and Mount Grand Magasin (2,117 feet). Slightly to the west of the central chain, there runs a short range of mountains of greater elevation, including Morne Howelmon (2,094 feet), Morne Gimie (3,145 feet), Piton Canaries (3,012 feet), Morne Custneau (2,946 feet), and many others.

A large block, occupying the centre of the island, and comprising about one-fourth of its area, constitutes the Crown Lands of the Colony. This area includes all the mountains mentioned in the foregoing paragraph, as well as the head-waters of all the principal rivers. A very important region from the point of view of forestry is thus under Government control. Since much of this land consists of fertile valleys which appear to offer inducements for cultivation, there is a desire to dispose of areas suitable for growing crops to persons who will undertake to work them, and it is hoped that as time goes on, a very considerable development of the island's resources may result therefrom and that there may be a substantial increase in the number of valuable properties. In the course of such development, however, precautions must be taken to safe-guard the position as regards the preservation of forests, the protection of ridges and water-shed and the sources of the principal rivers and streams. The regulations made on April 28, 1899, under the Crown Lands Amendment Ordinance No. 6 of 1890, enable such control to be lawfully exercised.

Under these regulations it is required that applications made to the Commissioner of Crown Lands for the purchase of them must be referred to the Governor-in-Council under certain circumstances, as follows :—

(1) When the area is more than 10 acres.

(2) When the area is less than 5 acres except such land forms part of a town or village or there are exceptional circumstances connected with it.

(3) When it is more than 1,000 feet above sea-level.

(4) When it is within 200 feet from the top of steep ridges which are less than 1,000 feet above sea-level.

(5) When it is within 33 feet of the top of the banks of any river or stream.

(6) When it is on any hill of forest timber which may be considered necessary for the storage of rain or moisture.

Arising in these hills are numerous rivers, some of which assume considerable size by the time they reach the coast. The principal ones on the west side are the Choc or Union River, the Cul-de-Sac and Roseau Rivers following roughly parallel courses from about the centre of the island and emptying into the sea at points approximately 2 miles apart. The Anse-la-Raye, Canaries and Soufrière, are on the west, the Doree and Vieux Fort Rivers on the south, the Canelles, Troumasse, Volet, Fond, Praslin, Dennery and Marquis occur on the east. In addition to these substantial streams, there are numerous others. The island, therefore, is remarkably well watered.

A comparatively small part of St. Lucia is under cultivation. The greater part of the island is covered with majestic forest and dense tropical vegetation. The cultivation occupies the valleys and even some of the slopes up to 1,000 feet; the high ridges remain untouched. As matters now stand, there is an abundance of forest-covered land, so that it is merely a question of assuming that such reasonable control will be exercised, and such prudent measures shall be laid down, as may preclude the possibility of disastrous denudation in the future, as agricultural progress makes demand for fertile land.

When an application for Crown Lands is sanctioned, it is stated in the grant that the area allowed is exclusive of roads, reserves and existing tracks. On the diagram of survey which accompanies the grant, the reserves for roads and those along the banks of rivers and streams, or any portion otherwise reserved are shown.

Parts III and IV of the regulations quoted, have specific reference to forestry. Part III gives power to the Governor-in-Council to proclaim any areas of Crown Land to be forest reserve, and to restrict the sale of any such areas as timber reserves, for the purpose in each case of preserving the growth and succession of timber trees and the water-supply, and of preventing as far as practicable, the destruction and exhaustion of forests.

Part IV, dealing with forest conservancy, empowers the Governor to appoint Crown Lands Commissioners, defines their powers, and the offences against forest regulations which they are required to deal with. Amongst other things, the regulations provide that no timber shall be cut on any Crown Lands at an elevation exceeding 1,500 feet, without an express license from the Governor-in-Council. Similarly, it is provided that no land belonging to the Crown, which lies at an elevation exceeding 1,500 feet shall be cleared or planted in provisions without

an express license from the Governor-in-Council—though these two regulations are not to affect the rights of any lessees of Crown lands.

Penalties are provided for the infringement of Crown Land regulations in relation to forestry.

Thus it will be seen that, in forestry matters, as far as Crown Lands are concerned, the Government has a free hand. The Governor-in-Council may dispose or lease any Crown Land, but the regulations restrict the sale, in ordinary cases, under the circumstances set out above; they also restrict the cutting of timber, or the clearing and cultivation of Crown Lands above 1,500 feet, though the Governor-in-Council is not bound by these restrictions.

Certain definite forest reserves have already been defined. The principal one is an area forming the catchment area for the Castries Water Works, and including the watersheds of some of the large rivers of the island. Portions of Crown estates, on the slopes of the ridges, have been reserved for a similar purpose. The total area thus demonstrated in this connexion contains about 3,313 acres, and extends from the vicinity of the Marquis estate on the north, to Crown Lands in the Cul-de-Sac Valley in the south. In other localities of the island, forest reserves have also been established.

Mr. E. D. M. Hooper reported on the forests of St. Lucia in 1886; he estimated the area of forest then existing as some 50,000 to 60,000 acres or approximately one-third of the whole extent of the island. It had not been disturbed at all on the central peaks but remained in its virgin state. Elsewhere, it had been more or less resorted to and cut, but of late years, he states, it had been left alone to resume its former growth. On the south-east, however, its original limit had been changed, and the extension of cultivation in Soufrèire and Choiseul had set it back to the head of the large valleys which start from the central hills themselves.

He further records that in composition, the forests differ but little from those in the neighbouring islands, though the deep soil allows of a denser and more diversified growth at higher and more exposed elevations than in St. Vincent. The chief features in the growth, he says, is the general distribution of Balata (*Mimusops* sp.), and other members of the natural orders *Sapotaceae* and *Laurineae*.

It may be taken that, in this Colony, the Government is in possession of the principal forests to which interest attaches in respect of the control of water-supply; at the same time there exist regulations for guidance, which, if carefully acted upon, should safeguard the Colony's position in this matter. As circumstances stand at present, the cleared and cultivated area bears a relatively small proportion to that of uncleared and uncultivated areas, so that care with regard to the preservation of forests is a matter for the future. Nevertheless, the Government, being thus in control of the situation, should keep steadily before it a sense of responsibility, and make careful use of those regulations now existing, which undoubtedly appear adequate for all ordinary purposes.

There still remains in St. Lucia a large area of forest land which may be cleared and cultivated without detriment, and, indeed, to the advantage of the island.

The progress of changes in forests and the need for care in their preservation would doubtless be well kept in mind by the preparation of short reports, at stated periods, as, for example, every four or five years.

Dominica.

The beautiful island of Dominica is the largest and most mountainous one in the Leeward and Windward groups. In the northern portion, and somewhat towards the western coast, is situated Morne Diablotin, having an elevation of 4,747 feet. From the highest point, prominent spurs and ridges run northward terminating in Morne au Diable (2,917 feet) in the extreme north of the island, and southward to the head waters of the Layou River, and its tributary the Laurent.

Along this main ridge are many points of high elevation, including Mosquito mountain, south of Diablotin, rising to 3,678 feet.

Running from the main ridge are many subsidiary ones trending chiefly towards the west coast. In the north-east direction, Morne Diablotin trends downward in magnificent sweeps towards the Lasoye quarter.

Also in the northern portion of the island, but to the westward and southward of the Diablotin range, there exists a prominent series of mountain masses (the main ridges of which run principally in northern and southern directions), the principal elevations in which are Morne Concord (2,106 feet), Morne Grand Bois (3,634 feet), Morne Laurent, Morne Negre Maron (2,417 feet), Morne La Source (2,318 feet), and Morne Bois Diable (2,389 feet).

Between the Diablotin range and that extending from Morne Grand Bois to Morne Negre Maron, lies a series of fine valleys, the southern portions of which are reached by the Imperial Road.

Many large rivers, and innumerable small ones, have their origin in these mountain ranges. Principal amongst those discharging themselves on the west coast, are the Layou, Maconcherie, Batalie, DuBlanc, and Picard Rivers. Running into the sea on the north-east coast, are the Hampstead, Tweed, Clyde, Pegoua and many others; whilst the Quanary escapes on the east coast at Castle Bruce.

The southern part of the island is filled with irregularly arranged mountain masses, the most northern of which, Morne Trois Pitons, contains three peaks having an elevation of 4,528 feet, 4,672 feet, and 4,552 feet, respectively. To the south of these lies the Lake Mountain (3,891 feet) and, still further south, a series of irregular masses contains the following: Watt Mountain (4,075 feet), Morne Anglais (3,748 feet), Morne Plat Pays (3,142 feet), Tete Morne (2,254 feet), and many others.

The principal rivers entering the sea in the southern part of the western coast are the Roseau, the Boery and the Mahaut, with many minor streams. The Geneva River discharges itself on the south coast. The principal streams on the southern part of the island, entering the sea on the eastern coast, are the Rosalie, the Tabery and the Mulâtre; but here again, as throughout the island, there are numberless other rivers, many of considerable size.

All these mountain tops and ridges are clothed with forest; the clearings which have been effected are situated on the flanks and lower spurs. The higher points and higher ridges are, as yet, untouched. There is, therefore, generally speaking, no immediate fear of damage from loss of forests. The matter of most immediate concern is that a wise policy of forest conservation shall be so thoroughly recognized and acted upon that, as land development takes place, no steps may be neglected to prevent excessive denudation. Only by such action can there be no vain regrets in the future.

The greater part of the interior land, including the mountain peaks and high ridges, constitutes Crown Land, and therefore, at the present moment, the Government controls the situation as regards the power to reserve as forest, whatever is necessary for the general welfare. In the efforts to develop the resources of the Presidency, the Government offers land for sale on easy terms. In this connexion, however, care is being exercised to prevent undesirable denudation. When Crown Lands are sold, it is stipulated that there is reserved a strip of 20 feet in width along each bank of all rivers and streams which pass through the land, and further that no land shall be cleared of forest within a distance of 2 chains (132 feet) from the source or feeder of any stream, nor shall any land be cleared of forest within 3 chains (198 feet) of the centre of any prominent ridge or dividing line of watershed.

No special forest laws exist in Dominica, matters pertaining to forests being dealt with under Crown Land regulations.

It is to be observed that a large part of the cultivation carried on in Dominica is concerned with the planting of trees, such as limes, cacao, rubber, oranges and the like, thus giving rise to conditions where the crop converts the cultivated area into a form of woodland having to some extent the same protective influences as forests.

The general interests of those who cultivate land in Dominica, render it necessary that they themselves should pay attention to the preservation of a certain amount of timber and woodland in order to prevent denudation. It is generally recognized that the clearing of land in districts liable to heavy rainfall may result in the washing away of the surface soil: the ordinary methods of agriculture are, therefore, directed towards the prevention of this loss, which is amongst the most serious that can befall the planter there. Thus arises in districts like this, a general body of knowledge and tradition leading to the use of shelter belts and soil covers, which are essential for the profitable carrying on of agricultural industries. Much may, perhaps, be done at this stage, by fostering educa-

tional campaigns and writings so as to create and maintain sound views on these subjects amongst landowners and the community in general.

A useful list of a large number of the timber trees of Dominica together with some of their characters and uses, is given in the *West Indian Bulletin*, Vol. IX, pp. 329-54.

The question of bush fires has received a good deal of attention in Dominica. This matter was dealt with at the third West Indian Agricultural Conference in 1901, by Dr. H. A. A. Nicholls, C.M.G., who read a paper on the subject and initiated a discussion: an account of this appears in the *West Indian Bulletin*, Vol. II, pp. 79-99. The paper is also reprinted as No. 4 of the Pamphlet Series of the Imperial Department of Agriculture, under the title: The Harmfulness of Bush Fires, by Dr. H. A. Alford Nicholls, C.M.G., M.D., F.L.S.

In this paper it is pointed out how, in July 1899, its writer moved a resolution in the Legislative Council of Dominica, expressing the desire to empower the Governor by legislative enactment to issue his proclamation in times of drought, forbidding for certain periods, under severe penalties, the setting of fire on any lands whatever, unless in special instances permission in writing be given by an authorized official. This resolution was passed unanimously, but it does not appear that legislation has been enacted to give effect to it.

In his paper, Dr. Nicholls gives instances of destructive bush fires, and urges the point that, in some places, the growth of a secondary forest is prevented owing to the destruction of young seedling trees by bush fires. He also instances the fact that an attempt many years ago, by the late Dr. Imray, to reclaim part of the dry, barren district known as the Grand Savannah, by planting young Ceara rubber trees, was frustrated by bush fires which swept over the plantation and killed the trees.

Montserrat.

This island, which has an area of some 47 square miles, is entirely volcanic, and possesses several boiling springs; it consists of two main mountain masses occupying the greater part of the middle and southern areas, together with minor hills on the northern extremity and on the western side. The principal mountain mass is situated in the southern part of the island, and comprises Chance's mountain, the highest point of which has an elevation of 3,002 feet, and South Soufrière (2,505 feet), there being numerous points having elevations of over 2,500 feet. North of the foregoing mass, and approximately in the centre of the island, is the second group of mountains known as the Centre Hills, the principal elevations of which are 2,450 and 2,400 feet. The northern extremity is occupied by a group of hills, the highest point of which, Silver Hill, rises to 1,285 feet.

The whole of the interior may be described as rugged and mountainous.

On the western side there is a small group of hills, of which Garibaldi Hill reaches an elevation of 840 feet, and there is a somewhat isolated hill in the south-west known as St. George's Hill, with elevations of 1,200 feet, and 1,180 feet. This is cultivated to the top.

The agricultural lands lie along the flanks of the mountains and hills, ascending up to varying heights, but in many places exceeding 1,000 feet, while the woods at higher elevations are in many places invaded by the provision grounds of the peasantry.

The higher portions of the main mountain masses are clothed with forest. This, however, was greatly damaged by the disastrous hurricane of 1899, which killed or injured a very large proportion of the trees. Immediately after this unfortunate visitation, many parts of the mountain area presented a bare appearance, the earth being visible at a distance between the seemingly dead trunks of the trees. In the time that has elapsed since then, the denuded areas have become covered with vegetation, and the forests are re-establishing themselves. In their present condition, the trees on these mountains take the form of low scrub, with here and there a taller tree which escaped total destruction in the hurricane. Many of these trees survived for a time, only to die slowly from the effects of their severe injuries, so that ultimately but few of the old forest trees survive. In many places where the destruction was extensive and large areas were laid bare, continuous growths of tree-fern have taken possession, forming a dense shade under which seedlings of forest trees can only establish themselves with difficulty. No botanical exploration of these forests has been made, so that there is little on record concerning the nature of the trees. The following may, however, be recorded: Gommier (*Dacroydes hexandra*), Red Cedar (*Cedrela odorata*), Red Wood (*Coccoloba* sp.), Bitter Ash or Quassia (*Simaruba amara*), Galba (*Callophyllum Calaba*), Fustic (*Xanthoxylum* sp.), Mastic (*Sideroxylon Mastichodendron*), Spanish Oak or Pois-doux (*Inga laurina*), Bay or 'Cinnamon' (*Pimento acris*), Locust (*Hymenaea courbaril*), Turpentine or Red Gum (*Bursera gummifera*), and *Lonchocarpus violaceus*, these two latter occurring principally on the lower elevations.

The forest areas appear to be all privately owned, so that the Government is not in possession of land suitable for the purpose of creating Forest Reserves.

In July 1901, an inspection of the island from the point of view of forestry and reforestation was made by Mr. C. S. Rogers, formerly of the Indian Forestry Service; as the outcome of this, legislative action was taken, and the Reforestation of Lands Ordinance was passed in 1903. This Ordinance creates a Forestry Board having three members, *ex officio*, and three to be appointed by the Governor. The Board has power to declare any area on which there may be timber to be a Forest Reserve, whereupon the area becomes subject to the regulations made by the Board for the preservation of the trees. Any person dissatisfied with the decision of the Board in declaring and constituting any area to be a Forest Reserve has the right to appeal to the Governor-in-Executive Council,

who may confirm, rescind, or vary the resolution of the Board. The Board has power to demarcate the areas declared to be Forest Reserves, and to make regulations controlling the management of the Reserves, the cutting and removing of timber, the burning of charcoal, or the cultivation of land therein. Areas declared to be Forest Reserves are exempt from the payment of land tax.

The Board has also power to regulate the kindling of fires in any district, and to make provision for the precautions to be taken for preventing the spread of fires.

No rules or regulations appear to have been made under this Ordinance, and it does not seem ever to have been put into force. The action taken which ultimately led to the passing of the Ordinance would, however, appear to have stimulated the interest of several of the local landowners, some of whom have exercised a certain degree of care in preventing depredations in the forest lands on their properties. The time would now seem opportune for enquiring whether the leading owners of forest lands on the higher mountains would agree to the areas above 1,200 feet being declared Forest Reserves.

Antigua.

This island presents three natural divisions: the north-eastern portion is composed of low limestone hills of varying geologic age, the oldest portions being probably Miocene; the middle portion of the island is occupied by a plain broken by minor hills: this plain which extends right across the island from St. John's Harbour to Willoughby Bay, is composed of sedimentary rocks probably of Eocene age which, by their weathering, give rise to clay soils for the most part under cultivation with sugar-cane. The south-western and southern parts of the island consist of broken masses of hills rising to a height of 1,330 feet in Boggy Peak, other elevations being McNish Mountain (1,204 feet), Signal Hill (1,130 feet), Falmouth Peak (1,058 feet), with many other points of lower elevation. The hills of this district are composed of the same series of rocks as those of the central plain; they have, however, been raised to the elevations mentioned by volcanic activity, intrusive masses of andesite being found in various parts. As the result of the volcanic activity, the rocks composing these hills have been so metamorphosed as to lead many observers erroneously to regard them as purely volcanic and resembling those of Montserrat and St. Kitts.

Antigua has been almost denuded of anything resembling forest growth. The tops of the hills, in the north-eastern or limestone district, are for the most part covered with low scrub, whilst among the hills of the south-western and southern part of the island, there are only a few places possessing groups of trees, and these cover no great area. The hillsides are for the most part covered with coarse grass, subject to fires at frequent intervals; such trees as remain, occupy the less exposed situations, being found in greatest numbers in the neighbourhood of Claremont and Cades Bay.

There are, in the island, fairly large areas of low-lying swampy lands, some of which are covered with tree-growths in which various mangroves (Rhizophora and Avicennia) figure conspicuously, whilst Whitewood (*Terminalia Buceras*) and Sea-side Grape (*Coccoloba uvifera*) also occur in some quantity.

Mr. E. D. M. Hooper, who visited this island in 1886, and reported on its condition in relation to forestry, states that there is little of interest from this point of view in the indigenous tree flora. He mentions, however, Whitewood (*T. Buceras*), White Cedar (*Tecoma leucoxylon*), Walnut (*Andira inermis*), and Logwood (*Haematoxylon campechianum*) as amongst the trees observed. He also refers to introduced trees, including Mango (*Mangifera indica*), Mahogany (*Swietenia Mahagoni*), Shak-shak (*Albizzia Lebbek*), *Melia indica* (or more probably *M. Sempervirens*), and Cedar (*Cedrela odorata*), which latter, for practical purposes, he regards as an introduced species.

To the trees mentioned by Hooper there may be added Locust (*Hymenaea courbaril*), Spanish Oak (*Inga laurina*), Hog Plum (*Spondias lutea*), Tamarind (*Tamarindus indica*), various species of Ficus, Sandbox (*Hura crepitans*), Silk Cotton (*Eriodendron anfractuosum*), and a few palms including Cabbage Palm (*Oreodoxa oleracea*), and Gru-gru (*Acrocomia sclerocarpa*).

Amongst the shrub growth, Hooper mentions various species of Acacia, *Prockia crucis*, *Calliandra purpurea*, *Caesalpinia pancijuga*, *Eugenia ligustrina*, *Samyda serrulata*, *Guettarda odorata*, *Catesbaea paniflora*, *Jacquinia armillaris* and *Brumelia cuneata*.

One of the commonest trees throughout the island is the Loblolly (*Pisonia subcordata*) : this occurs in clumps throughout the central plain, along roadsides and over the lower hills throughout the island. The existence of this tree is doubtless due to the valueless character of its wood : it finds no application in carpentry ; it is an indifferent firewood : and it is of no use for making charcoal.

The area of Crown Lands in Antigua is very small, so that any discussion directed towards the encouragement of tree-planting is largely concerned with land owned privately, and the stimulation of private enterprise. The Government is, however, in possession of an area of some 130 acres serving as the gathering ground for the collection of water for Wallings Reservoir, and proposals have recently been put forward for the reforestation of this area. The suggestions referred to have been formulated by Mr. H. A. Tempany, Superintendent of Agriculture for the Leeward Islands, who suggests that a considerable area may be enclosed and planted with various suitable trees, and the whole placed under the control of a forestry officer with a small staff. To carry this into effect, some expenditure, continued over a number of years, would be essential. The proposals are, in spite of this, well worth serious consideration, for the area affords the best opportunity which the island possesses for a practical attempt at reforestation ; while, at the same time, the proposals have reasons of

immediate utility in that they are calculated to equalize the flow of storm water from the gathering ground into the reservoir, and so increase the available supply.

It has recently been ascertained that various species of Eucalyptus, notably *E. rostrata*, *E. cornuta*, *E. tereticornis* and *E. citriodora* thrive extremely well in the low-lying lands in the island, and promise to provide material for growth in these localities where, hitherto, it has been found difficult to produce anything of value. This opens up possibilities in the way of forestry development which may be of the greatest importance to the island: the possibility now presented of raising useful and quick-growing timber, suitable for railway sleepers (for which there is now a considerable local demand), for stops, scantlings and firewood, will no doubt, give an impetus which may eventuate in a form of forestry likely to be of very great service both directly and indirectly. This question is now receiving the consideration of certain large landowners, and as an outcome, there may result something definite and effective in the way of tree-planting, whereby land, hitherto useless, may be profitably occupied and the condition of the island ameliorated.

No Forest Ordinances or regulations exist in Antigua: there is, however, a Bush Fires Ordinance (No. 5 of 1901). Under this, the Governor has power to prohibit by proclamation the setting of fire to any land within such times as may be specified. Owners of land desirous of setting fire to any land, are required to obtain a license for the purpose from the Surveyor of Works. In the application for the license it is necessary to state the locality of the land in question: after inspection, the Surveyor of Works may, if he thinks fit, grant a license, but the license may contain such conditions as he may think it desirable to impose, and may specify the days during which the license shall be in force. No license may be granted in respect to days during which the setting of fire is prohibited by the Governor's proclamation. Penalties are imposed for any breach of the Ordinance. In any trial or enquiry, the fact of fire occurring on any land is considered *prima facie* evidence against the owner, of his being responsible for the fire. Police constables are required to take steps to extinguish unauthorized fires, and to prevent their spread; and they, or any Justice of the Peace may call upon any male person present (whose age is between fourteen and sixty years) to assist them in these operations. Provision is made for the payment of one half of any fine to the person on whose information a conviction is obtained.

From the nature of the country, and from the fact that very considerable areas are covered with coarse grass easily inflammable in dry weather, intensive grass fires are common; these, sweeping over the country, destroy young seedling trees, greatly retarding any natural tendency to reforestation, and are a menace to any definite efforts in this direction. These fires are largely responsible for the denuded condition of a very considerable part of the country. The Ordinance referred to was designed to minimize this evil; it would appear, however, that it has not had the effect of fully checking it.

From its denuded condition, coupled with the dry climate and liability to drought, Antigua stands in greater need of efforts in the direction of tree-planting than most other West Indian islands. These efforts, it would seem, may most profitably lie in the direction of reforesting the gathering ground connected with Wallings Reservoir, and, perhaps, of certain water-collecting areas around the locality known as Body Ponds, and of the planting with Eucalypts of the low-lying lands in the central plain, particularly around Gunthorpes, Wiers, and Parham. With the cessation of grass and bush-fires, there would be a natural increase in the trees in the grass-covered areas of the central plain, and on the hills of the southern and western areas.

St. Kitts-Nevis.

ST. KITTS.

In form, this island is an elongated oval, with the long axis running north-west to south-east, prolonged by a curious narrow ridge into a small mountainous mass at the south-eastern extremity known—from the existence there of ponds from which brine is gathered—as the Salt Ponds. The central portion of the main part of the island is occupied by an important mountain range following, roughly, the island's axis, but turning somewhat to the southward at the south-eastern end. This range contains many points of considerable elevation. At the north-western end are Mount Misery (4,314 feet), the Crater (3,734 feet), together with other points considerably over 3,000 feet. A little distance to the south-east lies a cluster of peaks, known as the Middle Range, containing points of 3,574 feet, 3,336 feet and 3,153 feet; whilst still further to the south-east, there is the South-East Ridge containing numerous elevations in the neighbourhood of 3,000 feet, the highest point being 3,317 feet.

These central masses of mountains are well clothed with forest so far as their summits are concerned; the cultivated areas and pasture lands tend, however, to reach a somewhat high level in places, and to encroach upon them. The value of these forests as a means of conserving water is well recognized, for it is from the forests of these heights that the island derives directly its water-supply. By this is meant the public water service; though, doubtless, the lower lands, under cultivation, reap continuous benefit from the slow diffusion of moisture from the stores in the forest. At times, however, and in places, there may be evidence of want of care, and undue encroachment may be made. It is to the conservation of these forests that attention must be directed. The scrub covering the lower hills which exist in the south-east of the island is of little importance in this connexion, though an increase of the timber on these lower hills might ameliorate the conditions in their immediate neighbourhood.

As the forests of the higher mountains belong to the adjacent estates, and are not Crown property, it is not

altogether easy to ensure that they may be adequately protected. The question has been frequently discussed, and particularly as the outcome of observations made by the former Surveyor of Works, Mr. L. M. Kortright, who drew attention to the damage done by floods which he believed to be increasing in severity owing to the clearing in places of the mountain lands. As the outcome, a Forestry Ordinance (No. 10 of 1903) was passed.

This Ordinance makes provision for the creation of a Forestry Board, whose duties extend also to the island of Nevis: upon this Board devolves the duty of carrying out the regulations for the prevention of deforestation, and the plans for reforestation. In order to prevent deforestation, it is ordained that on and after the coming into force of the Ordinance, no person shall clear any land that is in forest, for the purposes of cultivation or for providing pasture or for other purposes without a permit from the Forestry Board; similarly, no timber may be cut or felled without a permit, though there are exemptions to allow timber to be cut for fuel for the use of any sugar factory on the estate on which the timber is growing, or for use in various constructions, or for the domestic use of the owner, employees, or labourers on the estate, or for sale for certain defined fuel purposes within the Presidency; but in this latter case the Board may make regulations to control the cutting.

The burning of charcoal is subject to restriction under the Ordinance; no charcoal may be burned without a permit, each permit being in force only during the calendar year in which it is issued.

No timber or charcoal may be exported from the Presidency without a permit from the Board.

Any person who may feel aggrieved at the refusal of the Board to issue any permit authorized by the Ordinance, may appeal to the Governor-in-Council.

In order to effect reforestation, the Legislative Council has the power to declare by resolution that any estate is subject to the provisions of the third part of the Ordinance, under which the Forestry Board is empowered to prepare a scheme for the reforestation of the estate in question, and the Governor-in-Council may give orders for the scheme to be carried out. Various safeguards are provided so as to prevent any injustice or injury to individuals or property from execution of the Board's plan, and for meeting objections to it, or amending it. When all has been approved, the owner of the estate is empowered to carry out the scheme of reforestation under the control and direction of the Board, and to be paid for carrying out thu work such sums as the Board may fix. In the event of any owner declining to carry out the work, the Board may undertake it.

The Board has powers to make rules and regulations respecting the cutting and felling of timber for local use or for sale, the burning of charcoal and the prevention or regulation of bush fires.

The writer is not aware that any scheme of reforestation has been carried through under the provisions of the third part of the Ordinance. The effective carrying out of the provisions of the second part should, however, have the effect of preserving the important forests of the central mountains, the existence of which are of vital importance to the island.

NEVIS.

Situated at a distance of some 3 miles from the south-eastern extremity of St. Kitts, lies the island of Nevis. It is almost circular in outline, the centre being occupied by an extinct volcanic peak 3,596 feet high, from which the land slopes away to the sea; the even slope is, however, broken by minor ridges, as near Maddens where an eastern spur runs out having a point of 2,350 feet, whilst on the south. Dunbar Hill is 1,194 feet, and still further south, there is Saddle Hill (1,432 feet). Thus Nevis may be regarded as having practically one central mountain, with Saddle Hill as a detached peak to the south.

The central mountain is covered with forest much as is that of St. Kitts and, like the forest of that island, forms the reservoir for conserving water upon which the island draws its supply. Its conservation is of great importance to Nevis, for should the forest area be seriously diminished, the sources of the public water-supply may be dried up, and possibly some of the lower slopes now under cultivation may be rendered less productive owing to the reduction of an available supply of subsoil water.

The Forestry Ordinance referred to in connexion with St. Kitts applies to this island also, and may be made the means of checking any tendency to encroach upon, and destroy the forest, if its provisions are carried out. The forests surrounding the peak are owned privately; it is desirable, therefore, that the owners should realize to the full the importance of an adequate conservancy. The provisions of the second part of the Ordinance, afford means for prevention of deforestation, and it would seem that reasonable care in preventing undue cutting of timber may suffice to maintain and even to extend the forest Should there appear danger of any diminution of the forest, the provisions of the third part of the Ordinance may be had recourse to.

The Virgin Islands.

This land consists of the group of numerous islands lying immediately to the eastward of Porto Rico, forming a chain some 60 miles in length. The islands at the western end of the chain, including St. Thomas and St. John, belong to Denmark; those situated in the eastern part are British. The largest of these are Tortola, Virgin Gorda and Anegada, in addition to which are numerous small islets.

Tortola, the seat of Government, is a somewhat long, narrow island about 12 miles by 3 miles at its broadest part, having a ridge of hills along the main axis which runs approximately N.E. to S.W. The island is sparsely timbered,

the hills being for the most part bare with small collections of tree growths in places, particularly in a few sheltered ravines. In places, the lower slopes are covered with scrub, while along the coast there are, at intervals, areas of mangroves covering the literal flats. There is scarcely anything in the nature of forest capable of effectively conserving water.

The conditions as regards tree-growths are very similar in Virgin Gorda.

Anegada, which is a low coral reef and sand island raised only to a small elevation above the sea, has little in the nature of tree-growth of any considerable size.

There are no forestry regulations nor any Ordinance for preventing or controlling bush or grass fires. Dr. Britton, Director-in-Chief of the New York Botanic Garden, has drawn attention to the highly specialized nature of the flora of this island, which is strikingly Bahamian. It was noted that two kinds of palms exist wild whose botanical affinities are at present unknown: one is a palmetto (sabal) and the other a thatch palm (probably Thrinax).

There is little doubt that the condition of Tortola and Virgin Gorda would be considerably ameliorated if it were possible to increase the number of trees, and to clothe the summits of the hills and the prominent ridges with timber. This question has had consideration and has been the subject of much correspondence. The difficulties, however, in the way of formulating any workable schemes are very great. The land is in the hands of private owners, many of whom are peasants, the Government being in possession of but limited areas, and these not embracing hill tops or prominent ridges.

The revival of interest in agriculture, and the attendant planting of cotton, limes and other crops, afford some basis for inculcating the advantages of wind-breaks, and it would seem as if one must be content for the present with such improvements as may be the outcome of the efforts of the agricultural officers to induce landowners to establish wind-breaks, and to prevent the further destruction of existing trees. At the same time, a careful watch may be kept in order to take advantage of any opportunity to carry into practice, on Government lands, the principles it is sought to induce others to follow.

It is interesting to record that, as the result of Dr. Britton's observations made during a recent botanical expedition to the Virgin Islands already referred to above, he has arrived at the conclusion that the trees on the summit of Sage mountain (1,780 feet)—the highest point in the Virgin Islands group—represent the remains of a primeval forest, and that there are present unidentified forms of considerable botanical and scientific interest.

In view of this, Dr. Britton has put forward the suggestion that it would be a matter of scientific importance to create a reserve for the preservation of the remains of this primeval forest. The matter is perhaps one that may attract the atten-

tion of botanists and of learned societies on both sides of the Atlantic, and it is hoped that it will receive careful consideration before complete destruction of the trees renders action futile. As many of the trees bore neither flowers nor fruit at the time of Dr. Britton's visit, he was unable to make a complete botanical determination of the species represented. An exhaustive botanical exploration of this small area is a matter of very considerable interest, that might well engage immediate attention.

STOMATAL CHARACTERISTICS OF VARIETIES OF SUGAR-CANE.

BY W. R. DUNLOP,

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So far as the writer is aware, the only important contributions to the study of the economic aspect of stomatal characteristics along lines followed in this paper are those of Kolkunov,[1] and of Jahushkine and Vavilov[2]. The former investigator has claimed to have shown that in wheat the degree of drought resistance, early or late maturity, and winter-resistance, depend largely upon the anatomical peculiarities of the plant, and especially on the size of the stomata. Jahushkine and Vavilov's researches, of a similar kind, were carried out with varieties of oats. These investigators arrived at the conclusion that the size of the stomata can be taken as a variety characteristic; but no correlations between stomatal and physiological characteristics could be traced, thus not confirming Kolkunov's conclusions in regard to wheat. In connexion with the susceptibility of the leaf to rust (*Puccinia coronifera*, Kleb.) negative results were obtained by these workers, which agree with conclusions previously arrived at by Marshall Ward and Eriksson. In view of the modification of ideas regarding the doctrine of correlation brought about by the influence of Mendelism, and in view of the fact that such characteristics as drought-resistance, disease-resistance and yield are functions of many factors, these negative results were regarded as neither improbable nor unexpected.

In regard to work on stomata from an aspect more purely botanical, Brown and Escombes'[3] generalizations on the subject of diffusion capacities of these organs, both in regard to assimilation of carbon dioxide and transpiration are in agreement with

results obtained later by Lloyd and others. This latter investigator working with *Fouquieria splendens* and *Verbena ciliata*, comes to the conclusion that stomata are not adaptive in the active sense, not regulatory in their function, but effective upon transpiration only through a suppressive effect of constant value depending upon their size and number. Lloyd[4] found, for instance, that the rate of transpiration may increase after the maximum size of the stomatal pore has been reached, and continue to fall after the stomatal closure (short of entire closure) is complete. Transpiration extremes are, of course, frequently limited by co-ordinate leaf-movements and by the presence of emergencies, but such means of regulation must not be confused with movements of the guard-cells of the stomata themselves.

Balls,[5] however, working with the cotton plant in Egypt states that his results are different, and point to the great importance of stomata in regulating transpiration. This conclusion does not appear to be altogether borne out by his observations. For instance he says: 'On hot dry windy days the full aperture has scarcely been attained [by 9 a.m.] before closure sets in. Such facts indicate that the closure which follows must be due to 'water-supply' shortage, and that its utility is to check the excessive water loss involved by free transpiration. By noon, in most summer days the closure is almost complete.' Later, in discussing transpiration, he observes: 'Transpiration is practically in abeyance at night, slow in the early morning. By 9 a.m. in sunshine it has reached a maximum which is maintained till past noon.'

These two results do not appear to show the existence of any great regulatory action thereby strengthening the results of Lloyd and of Brown and Escombe.

Present Investigation.

In ignorance of the Russian researches, the writer, two years ago, noticed the existence of constant stomatal characteristics in varieties of sugar-cane. The idea of investigating the subject originated through considering Brown and Escombe's generalizations in conjunction with the vast economic importance of water and carbon dioxide in relation to the sugar-cane.

The West Indian island of St. Kitts, where most of the observations were made,* presented favourable conditions for profitable study, for in the Presidency, a large number of different varieties of sugar-cane are grown experimentally under field conditions in localities presenting within a small radius, similar soil, but remarkably different climatic characters.

After a considerable amount of speculative microscopic examination of leaves, it was decided that marked stomatal differences might best be detected by an examination of those varieties which were known to be resistant or otherwise to

* Specimens for comparison of the more interesting types of leaves were kindly sent to the writer from Barbados, by the Imperial Commissioner of Agriculture; from Antigua, by the Superintendent of Agriculture for the Leeward Islands; and from British Guiana, by the Director of the Department of Science and Agriculture.

drought, and by examining leaves of different sizes and habits irrespective of accumulated facts concerning general adaptability. Out of some thirty varieties investigated under this system, the ten dealt with in the following pages exhibited constant features of considerable interest.

D. 642.

The parent of this variety is the Bourbon cane. In St. Kitts this cane exhibits marked hydrophyllous characteristics. The leaf is large (some 1,000 sq. cm. in area), pendulous and devoid of hairs and wax. It never curls. In very dry weather, however, it wrinkles slightly along the ribs. The epidermis is remarkably thin, and the highly protoplasmic cells appear to be somewhat poor in chlorophyll. The leaf of this variety represents the group of canes possessing stomata in the greatest density. The upper surface contains about 20,000 stomata per sq. cm., and the lower surface about 34,000 per sq. cm. An average size leaf would therefore contain about 54,000,000 stomata. The individual stoma is somewhat below the average in size, the length of the diameters of a partially closed stoma being about ·035 and ·02 mm. (approximate area, = ·00055 sq. mm.). The stomata therefore occupy about 29·4 per cent. of the leaf's entire surface area.

B. 4030.

This was one of the most interesting varieties that came under observation. The leaf is rather large (some 800 sq. cm. in area), but in St. Kitts it seldom attains the size of a leaf of D. 642. As regards habit, it is very erect. In texture, it is tough. The leaf blade curls, as a permanent habit, protecting the lower surface. The epidermis is thick—frequently a well developed hypodermis is present. The motor cells are prominent and large, and are generally firmly attached by woody cells to the vascular bundles which are situated comparatively close together. Like D. 642, the leaf of this variety possesses a large number of stomata per unit of area on the lower surface (on an average about 30,000 per sq. cm.). On the upper surface there are fewer, namely about 14,000 per sq. cm. An average size leaf therefore contains about 35,200,000 stomata. The individual stoma is somewhat above the average in size, the length of the diameters of a partially closed one being about ·04 and ·03 mm. (approximate area, = ·00089 s.q. mm.) The stomata therefore occupy as much as 39·2 per cent. of the leaf's entire surface area.

D. 1108.

This variety has been under trial for several years, and has given very satisfactory returns in the Leeward Islands, and elsewhere. It appears to be moderately resistant to drought. The leaf is rather narrow, and has an average area of about 600 sq. cm. In habit, it is rather erect, and it possesses a more or less permanent habit of curling, to protect, not the lower but the upper surface The motor cells are rather small and the epidermis is not remarkably thickened. The upper surface of the leaf possesses about the same number of stomata per unit of

area as B. 4030, but a rather less number on the lower side (28,000 per sq. cm). An average size leaf contains about 25,200,000 stomata. The individual stoma is about the average size, namely, ·04 by ·025 mm. (approximate area, = ·00066 sq. mm.). The stomata therefore occupy about 27·7 per cent. of the leaf's entire surface area.

B. 208.

Perhaps no other Barbados variety is better known than B. 208. As regards its economic characters, it possesses an exceptionally high sucrose content, but for successful growth, it requires good conditions of soil and climate. It is unsuited to districts of low rainfall. The leaf is very large (about 900 sq. cm. in area) but when grown under the same conditions in St. Kitts it seldom attains the size of that of D. 642. The leaf of B. 208 is characteristically erect in habit. During periods of drought, the leaf-blade tends to curl slightly to protect the upper surface, but this habit is not permanent, nor is it pronounced, as in the case of the leaves of the two varieties just described. The leaf is rather thick, dark green, and generally covered with wax. The epidermis is greatly thickened, and a considerable amount of woody tissue is to be observed girdering the vascular bundles to the epidermis. The number of stomata per unit of area seems to vary considerably in this variety but on an average it possesses fewer than that of D. 1,108. For the upper surface, 12,000 per sq. cm. may be taken as a representative figure, and 25,000 per sq. cm. for the lower surface. An average leaf would therefore contain 32,000,000 stomata, which approaches very nearly to the total number for B. 4020. The individual stoma is large (about ·00089 sq. mm. in area). The stomata therefore occupy about 32·7 per cent. of the leaf's entire area.

D. 109.

This variety has also been cultivated for many years, and has given satisfaction in many different localities. The leaf is inclined to be narrow, but it is rather long. The area is about 600 sq. cm. It exhibits some tendency to curl, protecting the upper surface. As regards the number of stomata per unit of area, this leaf resembles an average leaf of the B. 208 type, but because of its smaller area, a D. 109 leaf contains only about 22,200,000 stomata compared with 32,300,000 for a leaf of B 208. The stomata occupy about 24·3 per cent. of the leaf's area, a much lower figure, it will be noticed than that for B. 208.

WHITE TRANSPARENT.

This variety has the reputation of being able to withstand dry conditions. The leaf is inclined to be rather large (800 sq cm. in area). It does not possess any very pronounced characteristics except as regards the upper epidermis, on which minute hairs are often abundant, whilst the number of stomata per unit of area is rather below the average. The number on the lower surface is about the same as in the case of D. 109 and B. 208. The total number of stomata on a normal leaf is approximately 28,800,000. The individual stoma is of the average size. The stomata therefore occupy only about 23·8 per cent. of the leaf's surface area.

D. 1111.

The chief feature of the leaf of this variety is the combination of a rather large size (800 sq. cm.) with low stomatal density. On the lower surface, seldom more than 23,000 stomata were counted on an average per sq. cm., whilst on the upper surface few of the leaves examined contained more than 9,000 per sq. c.m. A normal leaf would therefore contain about 25,600,000 stomata. The individual stoma, however, is of the large type (·00089 sq. mm.) and therefore the stomata occupy 28·6 per cent. of the leaf's total area.

B. 1753.

From its general appearance, alone, this variety shows remarkable deviations from the normal. It has given very good results both experimentally and in cultivation in Barbados and the Leeward Islands, but it has shown in many localities a susceptibility to dry weather conditions.

The leaf is very narrow, and has an area, on the average, of only 450 sq. cm. In habit, the leaf is very erect, and exhibits a marked and permanent tendency to curl, protecting the upper surface. The leaf blade is rather light green in colour.

As regards the stomata the upper surface contains 11,000 per sq. cm. which is *relatively* great compared with 20,000 per sq. cm. for the lower side. An entire leaf contains only about 13,950,000 stomata—the fewest number calculated in the case of the ten varieties of sugar-cane examined. The size of the individual stoma is of the medium type, so that the stomatal area occupies only 20·4 per cent. of the leaf's entire area.

SEALY SEEDLING.

This variety is, in some respects, not unlike B. 1753. Its leaf is larger, however, (600 sq. cm.) and the variety has gained a reputation for hardiness by which is meant capacity for tiding over short periods of drought, flood and epidemics of disease.

Although the leaf contains about the same number of stomata per sq. cm. as B. 1753, on its lower surface, it has fewer on the upper, generally about 7,000 per sq. cm. There are thus about 1,620,000 stomata to a leaf. The individual stoma is of the large type. Hence the stomatic area would appear to occupy about 24 per cent. of the leaf's total area.

D. 116.

The last variety and perhaps the most interesting one to be considered is D. 116. This cane has been grown successfully in dry localities, and like D. 109, is a typical Demerara cane suited to conditions obtaining in St. Kitts.

D. 116, has a large leaf (average 800 sq. cm.). It is rather pendulous in habit with no pronounced curling tendencies. The veins are very parallel and wide apart. The texture is moderately soft. The external characteristics, are in fact, markedly hydrophyllous.

The upper surface of the leaf, however, contains only some 7,000 stomata, per sq.cm., situated close under the ribs of the veins. On the lower surface seldom more than 20,000 were counted per sq. cm. This gives a total of 21,600,000 for the entire leaf. The individual stoma is of the large type, and hence the stomata in spite of their very low number per unit of area occupy 24 per cent. of the leaf's entire surface.

Curling.

This habit of the cane leaf has been referred to shortly in the above account of each variety. There is no doubt that curling is correlated with stomatal characteristics, with the anatomical structure of the leaf and that it is one, if not the most important mechanism regulating the leaf's processes of gaseous interchange.

Involute curling (upper surface protected).

This is a pronounced habit of the leaves of B. 1753 and D. 1108 under normal conditions of growth, and occurs to some extent in most varieties during a period of very dry weather. D. 642 and White Transparent are two varieties which do not readily curl even under conditions of drought.

The following anatomical characteristics are common to those varieties which readily curl involutely:

(a) Motor cells are not prominent.
(b) The cells immediately interior to the motor cells are generally comparatively large and thin walled.
(c) The upper epidermis is not greatly lignified.
(d) Relatively large number of stomata on upper surface.
(e) Leaves are never very broad and are generally erect.

The fact that involute curling is most pronounced in the field during dry weather indicates that the habit is a sign of desiccation.

It should be pointed out that involute curling (and also revolute) is never complete in the leaf while it is attached to the plant (except in the case of developing leaves). But if a curled leaf be removed, it curls up completely in involute form, irrespective of its habit when attached.

Revolute curling (lower surface protected).

Amongst those varieties whose leaves have been observed in St. Kitts—in some cases in Antigua also—to curl revolutely, may be mentioned B. 4030, B. 6450, B. 3859, and B. 3696.

The following characteristics are common to the leaves of these varieties:

(a) The motor cells are prominent and large.
(b). The motor cells are generally firmly attached to the vascular bundles opposite to them by woody cells.
(c) The vascular bundles are comparatively close together.
(d) The upper epidermis is greatly lignified.

(e) In some cases the motor cell groups appear to be connected by means of water storage cells with the stomata on the lower surface.

(f) Relatively large number of stomata on lower surfa ce

Revolute curling appears in St. Kitts and Antigua to be a permanent characteristic of those varieties named. The habit has been observed in two successive crops of plant canes—the second one being grown from cuttings taken from the first.

The habit is not affected by light or darkness and occurs irrespective of changes in the weather.

When a revolutely curled leaf is detached from the plant it straightens out beginning at the base, and then curls involutely until it is completely rolled up—a very remarkable habit.

But if a revolutely curled leaf be placed, immediately after detachment, in water it retains its revolute form ; but on being removed from water and allowed to dry, it proceeds to curl involutely until it is completely rolled up as in the former case.

CURLING AND TRANSPIRATION.

Although systematic transpiration experiments have not been carried out, several quantitative tests were made, from time to time with the leaves of different varieties in the following manner. Large test-tubes fitted with split corks and containing a small quantity of calcium chloride were weighed and taken into the field. One of these tubes was fitted with a thermometer for determining the internal temperature and for purposes of control. The ends of growing cane leaves were introduced into the tubes which were kept at a temperature of 30° C. by spraying the tubes with alcohol. The tests were made in strong sunlight and in diffused light. In consequence of their position, the leaves were unable to curl to any great extent. It was found that the amount of moisture given off in half an hour in sunlight was considerable and varied to a remarkable extent with the stomatal density of the respective varieties of leaves dealt with. It was concluded from these tests that in all probability the stomata in the cane planthave little regulatory action whilst further trials with cane plants grown in large tins seemed to show that curling was the fundamental regulator.

Ratio between Transpiring and Non-transpiring Surfaces

It was thought that it might prove illuminating to determine as far as possible what relation the area occupied by tbe stomata in the entire foliage bears to the total area of leaf surface.

To obtain the total stomatal area in any variety, utilizing the results already obtained, it is only necessary to know the number of leaves.

The number of leaves normally borne by a variety of sugarcane at any one time in its life history is not altogether determined by conditions of environment. The feature of growth which mainly influences in a constant manner the number of leaves borne is the number of culms to the stool. In this respect many varieties possess pronounced characteristics. As regards the

number of leaves to the culm, a well developed cane irrespective of variety bears about ten at any one time, though of course the total number borne during its entire growth is given by the total number of the nodes produced. It would be interesting to know to what extent stomatal characteristics favour or retard the production and the period of functional activity of leaves of sugar-cane varieties. It may be pointed out in passing that the development of the sugar-cane plant is of an extremely mathematical nature. For instance, the total number of nodes divided into the number of time units occupied in developing gives a figure which is proportional to the leaf's period of functional activity. Observations in this direction would be of very great interest and possibly of economic importance in connexion with early maturity.

Returning to the main point at issue, it is not impossible to obtain a fair idea of the difference between the number of leaves normally borne by two varieties growing under similar conditions provided a constant variation exists in connexion with the number of culms to the stool.

It will be convenient to take suitable examples, namely the cases of B. 208 and B. 1753. Three things are certain: (1) the leaf of B. 208 is always much larger than that of B. 1753; (2) B. 1753 has always a larger number of canes to the stool, and therefore a larger number of leaves than B. 208; (3) B. 208 has a greater number of stomata per unit of area, which are individually larger than in the case of B. 1753.

The product of these factors must be of a constant nature. It was thought that it would be interesting to determine the difference quantitatively, and the result is shown in the following table:

	Av. no. of canes to stool.	Total no. of leaves.	Total foliage area sq. cm.	Total stomatal area, sq. cm.	Ratio of non-transpiring to transpiring surface.
B. 208	12	120	108,000	35,280	3·0:1
B. 1753	18	180	81,000	16,560	4·9:1

It will be observed then that these two varieties differ remarkably as regards the ratio of transpiring to non-transpiring surface. Determinations of the same kind in connexion with the other eight varieties showed that they all with the exceptions of D. 642 and B. 4030 (which tend to approach more closely to B. 208) occupied an intermediate position between the ratios for B. 208 and B. 1753, although every variety appears in this respect to possess a constant ratio, in spite of fluctuations.

In St. Kitts, under the conditions that these observations were made, both B. 208 and B. 1753 are susceptible to dry weather conditions.

It is interesting to note that D. 642 with its high stomatal content is also susceptible. More noteworthy still is the correlation

between the habit of curling exhibited by B. 4030, and the high stomatal content of this variety. The subject of curling has been dealt with in another place in more detail.

Before leaving the subject of transpiring and non-transpiring areas it may be pointed out that an interesting consideration is the relation of the extent of root system to the stomatal area.

Varieties with many canes to the stool must necessarily have an extensive root system which in a field will tend to occupy the whole of the surface soil. Hence there is little reserve moisture. This circumstance is of importance in regard to B. 1753 which seems to require a rapid, continuous supply of water no doubt to keep its foliage at a suitable temperature. B. 208 has a less extensive and a deeper root system, and although it requires deep soil and a good annual precipitation it does not appear to be particularly susceptible to short periods of drought. There is all the difference between a variety being suited to conditions of low annual rainfall and being suited to an uneven distribution.

Summary and Discussion.

Certain groups of varieties of sugar-canes possess differentiating characteristics as regards their stomata. If the general morphological and anatomical characteristics of the varieties examined be taken into consideration, each one variety can be identified by its leaf alone.

The stomatal densities per unit of area is one of the chief characteristics, though in the present investigation the range of variation has not been determined with sufficient accuracy to permit more than the classification of the varieties examined into groups as regards stomatal densities. There appears to be no definite correlation betweeen stomatal density and other constant factors like size of leaf, size of the individual stoma and the total area of the foliage, though where the stomata are very numerous they are often particulary small and *vice versa*.

Hence the effective stomatal feature of any variety can only be arrived at by taking the product of these different factors. This may be termed the total stomatal area.

So far as the present observations go, there is some indication that susceptibility to drought is affected by extremes as regards the ratio of the total stomatal area to the entire area of the foliage; but in this connexion further work in genetics and physiology are necessary.

The manner of curling is probably more important in limiting the effective action of the stomata, than the stomata themselves. This habit is correlated with the ratio between the stomatal densities on the surfaces of the leaf, with the anatomical structure (motor cells and woody tissue) and with the erect position of the leaf. Pendulous leaves do not curl except under desiccation.

It is likely that the distribution of certain varieties in cultivation would be seriously restricted were it not for the correlation between leaf habit and stomatal characteristics. This hypothesis is supported by the case of D. 642 which possesses a high stomatal area together with other hydrophyllous characteristics and seems unsuited for cultivation in areas of low rainfall and humidity.

EXPLANATION OF PLATES.

Plate I.

Camera lucida drawings of epidermis showing relative number, size and distribution of the stomata characteristic of the leaves of the following varieties of sugar-cane :—

1. D. 642 (lower surface). 2. D. 642 (upper surface).

3. D. 116 „ „ 4. D. 116 „ „

5. B. 208 „ „ 6. B. 208 „ „

7. B. 1753 „ „ 8. B. 1753 „ „

Plate II.

Camera lucida drawings of transverse sections of sugar-cane leaves.

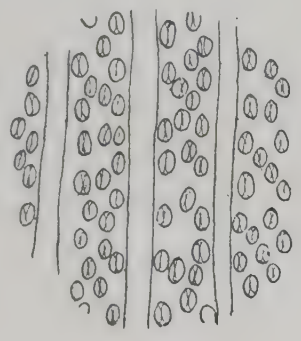
9. D. 1108, near midrib. Leaf not curled.

10. D. 1108. The same partially curled, protecting upper surface.

11. B. 208. Section farther from midrib and less highly magnified. Leaf slightly curled protecting the upper surface.

12. B. 3696. Partially curled, protecting lower surface. Motor cells prominent and girded to vascular bundles (shaded areas).

PLATE I



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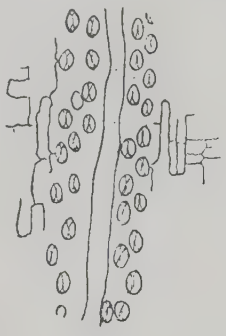

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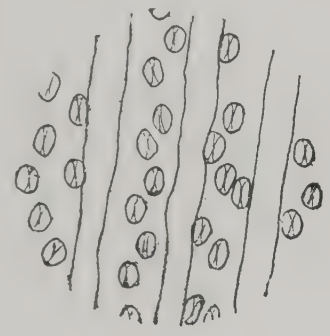

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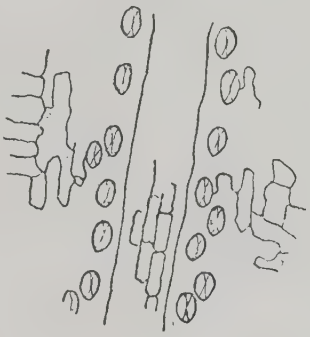

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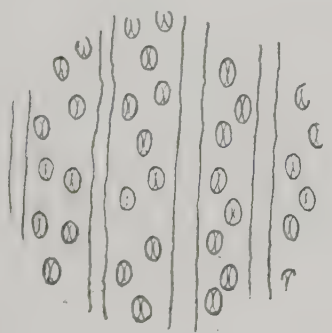

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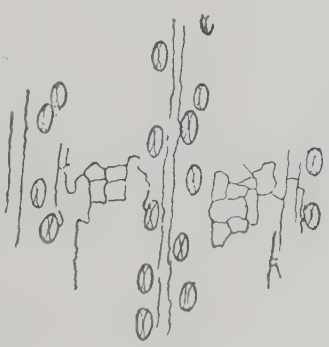

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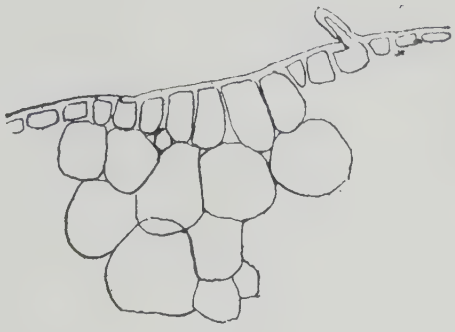
PLATE II.



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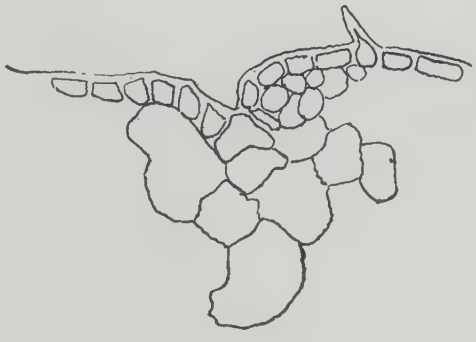

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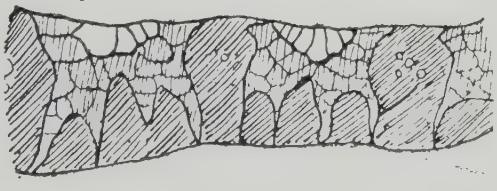

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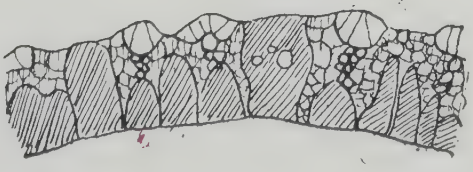

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If the anatomical features of the leaf of this variety were such as to permit it to curl, then in all probability this would allow of its more extended cultivation.

The question as to whether any general relation exists between the sucrose content of varieties and their stomatal characteristics has not been entered into, but it may be pointed out that B. 208 which has by far the greatest stomatal area, normally exhibits a very high sugar content. In this connexion the large extent of the leaf area rich in chlorophyll exposed to incident sunlight in the case of B. 208, is not without some significance. The relation, too, between early morning and evening sunlight and photosynthesis in erect leaves may be noted.

In the future selection of the sugar-cane for drought resistance, it is the opinion of writer that more attention should be paid to the habits of the leaves and their stomatal characteristics. A variety growing under unfavourable conditions suppresses leaf production. That suppression is a biological advantage, but not an economic one. A large amount of leaf area is desirable for the preparation of sugar by the plant, and it is in the nature of the plant to respond in this respect if provision has been made in its anatomy its cope with the limiting factor, water-supply.

As already expressed earlier in this paper, in view of recent work on the segregation of characters, the doctrine of correlation ceases to be as straightforward as it was once upon a time thought to be. The writer has therefore purposely refrained from attempting to draw any definite conclusions at present, but it is believed that the foregoing results will be found useful and suggestive in selection work of the future and little can be said further until this has been put to the test.

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CANE SYRUPS OR FANCY MOLASSES.

BY H. A. TEMPANY, B.Sc., F.I.C.
Superintendent of Agriculture for the Leeward Islands.

In the island of Barbados the manufacture of cane syrups, or as they are termed, Fancy Molasses, in place of muscovado sugar and molasses has been practised on muscovado sugar estates to quite a considerable extent for some years past.

The process of manufacture is similar in many respects to the operation of making muscovado sugar, but differs from it in that special precautions are taken to restrain crystallization of sugar. The finished product, if properly made, is a thick liquid, which on prolonged keeping evinces no tendency to deposit crystals of sucrose.

During the sugar crop of 1913, the low market price of sugar combined with the more remunerative values offered for syrups, has caused a good deal of attention to be attracted towards this method of dealing with the crop in the Leeward Islands Colony as well as in Barbados. Consequently the following summary of information is put forward in the hope that it may prove of value to producers.

At the present time, the Barbados product constitutes to a large extent, the standard article, and for syrups to be readily marketable it is necessary for them to conform to the requirements with the same degree of exactness.

The greater proportion of the syrups produced in this way enters into consumption in Canada, and under these conditions the requirements of a good syrup may be stated as follows :—

(1) It should possess a density of not less than 40° Beaumé; (2) it should test not more than 48° and not less than 32° by the polariscope ; (3) it should be free from fermentation and pronounced flavour of acidity ; (4) it should evince no sign of crystallization even on prolonged standing ; (5) it should be absolutely free from all traces of mineral acid ; (6) it should be clean, free from suspended impurities, bright, and of a good light-golden colour when viewed in small thicknesses.

Analyses of a number of typical samples of Fancy Molasses have been performed in the Government Laboratory for the Leeward Islands ; some of these are given below to illustrate the composition of the product : —

	I	II	III	IV	V
Sucrose	46·3	42·1	43·0	44·2	51·0
Glucose	27·3	32·8	30·7	24·4	20·0
Non-sugar ...	2·7	3·5	5·0	1·0	5·3
Ash	1·3	1·9	1·5	3·3	1·8
Water	22·4	19·7	19·8	27·1	21·9
Total ...	100·0	100·0	100 0	100·0	100·0
Direct polarization	39·9	35·0	35·1	36·2	47·5
Specific gravity, degrees Beaumé.	...	41·5°	41·2°	39·0°	41·0°

In sample No. IV, the specific gravity is somewhat too low, while in the case of No. V, the amount of inversion which has taken place is barely sufficient to restrain crystallization.

It is interesting to endeavour to ascertain what are the equivalent quantities of syrup and muscovado sugar and molasses. From calculations based on the composition as determined by analysis of a large number of muscovado massecuites, it has been found that the equivalent of 1 ton of muscovado sugar and 60 Imperial gallons of molasses is 273 Imperial gallons of syrup of density 40° Beaumé.

From these data it is a simple matter to calculate the equivalent value of syrup in terms of the market price of sugar and molasses. In a paper published in the *West Indian Bulletin*, Vol. X, dealing with the question of Central Factories, Dr. Watts put forward a statement showing the relative actual values of muscovado sugar and syrup based on market values for syrup. This table summarizes the position in a concise and convenient form and is reproduced below : the values for syrup are given both in Imperial and Wine gallons, since the latter measure is still in use in both Barbados and St. Kitts, and is the standard measure in the United States of America.

Value of 100 lb. of musco. sugar.	Value of 1 Imperial gall. of syrup in terms of the price of sugar.	Value of 1 wine gall. of syrup in terms of the price of sugar.
$1·60	16·7 to 17·0c.	13·9 to 14·2c.
1·70	17·8 to 18·1c.	14·8 to 15·1c.
1·80	18·8 to 19·2c.	15·7 to 16·0c.
1·90	19·8 to 20·3c,	16·5 to 16·9c.
2·00	20·9 to 21·4c.	17·4 to 17·8c.

In constructing this table the value of the molasses which would have resulted in any case has been deducted from both sides of the table, and the advantage in favour of syrups is given by the difference between the market price of syrup and the value given in the second and third columns, excluding the cost of package and any possible profit likely to be derived therefrom.

In concluding this section of the paper it may be remarked that the market price of syrup and that of muscovado molasses follow one another closely, and the entire question appears to resolve itself very largely into that of the relative prices of muscovado sugar and molasses. With muscovado sugar at a low price, and molasses and syrups selling well, it pays to make syrups; while when the reverse is the case, sugar-making seems likely to remain the more profitable undertaking.

Turning now to the consideration of practical questions relating to the manufacture of syrups, it may be once more stated that the essential difference between the manufacture of syrups and that of sugar lies in the fact that in the latter case the object sought is to induce as much sugar as possible to crystallize from the concentrated cane juice, whilst in the former it is to restrain crystallization altogether.

In order to secure this, it is necessary that a sufficient quantity of the cane sugar originally present in the juice should be converted into invert sugar, or, as it is more usually termed, in cane-producing countries, glucose. Invert sugar possesses the property not only of not crystallizing itself, but also of restraining the crystallization of cane sugar. It is formed by the action of acids on cane sugar, and it is termed invert sugar because it turns the plane of polarization to the left, whilst cane sugar turns it to the right. When cane sugar is converted into invert sugar, the polarization is changed from the right to the left and is said to be inverted; hence the origin of the term.

In syrup-making, therefore, the whole object sought is to convert a sufficient amount of cane sugar into invert sugar to prevent crystallization in the finished syrup.

Practically, any acid will effect the inversion of cane sugar, but the rate of inversion will depend on four things: (1) the strength of the acid employed; (2) the quantity present; (3) the temperature of the juice, and (4) the length of time of the reaction. Subject to the first two conditions, the reaction proceeds moderately rapidly at the boiling temperature, but is practically suspended when the liquid is cold; the most rapid inversion is secured when relatively strong acids, such as the mineral acids hydrochloric or sulphuric, are employed. The use of these reagents is, however, precluded in the manufacture of cane syrups for direct consumption, as their presence in the finished product is forbidden under the American and Canadian pure food laws. The removal of sulphuric acid is not a difficult matter to effect chemically, but in order to do so it would be necessary in practice to make not inconsiderable

structural alterations and changes in the sugar works available in these islands for the manufacture of syrups.

Consequently it becomes necessary to find some other reagent capable of causing the necessary inversion, the presence of which will not be detrimental to the finished syrup.

Under these circumstances various vegetable acids suggest themselves, notably tartaric acid, citric acid, or even lime juice: but here again it seems not unlikely that their employment in the requisite quantity would so increase the cost of the manufacture of syrup as seriously to diminish, if not entirely destroy, any profit likely to be derived from syrup manufacture.

Experience has shown that fresh cane juice naturally possesses a certain amount of original acidity and that this varies very considerably with the condition under which the cane is grown. In the case of cane grown on light volcanic non-calcareous soils with the accompaniment of a fairly heavy rainfall, such as occurs in the northern cane-growing districts of St. Kitts, it has been found that the natural acidity of the juice may in some cases suffice to effect the requisite degree of inversion, provided it is not neutralized by the addition of lime. Under these circumstances the securing of the necessary conditions in respect to acidity becomes a simple matter.

On the other hand, this by no means holds true in all cases. For instance, it is impossible to manufacture syrups from ripe canes such as are usually encountered on the calcareous soils of the northern and eastern districts of Antigua without the addition of acidity supplementary to that normally contained in the juice.

It is well known in these islands that raw cane juice, if it is allowed to stand, develops a marked amount of acidity and it is said to be sour.

This phenomenon has been investigated to some extent and has been found to be due to the presence of a specific organism which converts a portion of the cane sugar present into various organic acids.

This circumstance affords a convenient means for obtaining the requisite amounts of acid of a suitable character, and advantage has largely been taken of it in the manufacture of syrup in Barbados.

As practised there, the details of procedure appear to vary considerably with different workers, but the end sought is in all cases the same, namely, to obtain the requisite amount of acidity by the souring of cane juice.

From general principles it would appear that it is more desirable to secure the requisite degree of acidity by the addition of a known amount of sour juice to definite quantities of fresh juice, than by depending on a general sour tendency throughout the buildings to bring about the desired results.

From experiments recently made in the Government Laboratory for the Leeward Islands, it appears that in juice occurring in Antigua and St. Kitts under average conditions

the amount of acidity developed in the first twenty-four hours varies within relatively narrow limits.

Subsequently the rate of souring in the case of different varieties appears to be subject to variations of some magnitude.

From this it would seem that by employing fixed quantities of sour juice approximately twenty-four hours old to effect the necessary inversion, a certain degree of control is capable of being established with comparative ease.

Once this is done, there does not seem to be any reason why the same degree of cleanliness should not be observed in making syrup as in making muscovado sugar; in fact it would seem that a practice which would involve keeping the boiling house in a sour and dirty condition cannot be too strongly deprecated, since it must necessarily involve greatly added risk of contamination of the finished product with organisms likely to cause souring and other undesirable fermentation changes in the finished syrup.

From what has been said it is obviously not possible to lay down any hard and fast rule as to the quantity of sour cane juice which it is necessary to employ to effect inversion, since it may vary from nothing, as in the case of certain estates in the northern cane-growing district of St. Kitts, up to 60 to 80 gallons of sour juice twenty-four hours old, as has been found necessary in certain estates in the limestone area of Antigua. It is probable, however, that the amount necessary will vary with season, with the age and ripeness of the cane, and with the variety. Consequently would-be syrup makers must determine for themselves the requirements suited to the conditions under which they are working; this, however, need present no great amount of difficulty, since a few careful trials will soon afford the information needed.

We may now consider to some extent the details of the operation. This, of course, will in large measure depend on the manufacturer himself, and the equipment which he possesses.

The first point calling for consideration is the treatment of the juice after it leaves the mill and runs into the clarifier.

In the ordinary operation of sugar-making, the first step is the application of lime to the juice. Some diversity of opinion exists as to the desirability of 'tempering' in the manufacture of syrup. Personally, the writer is inclined to the opinion that the operation can very well be conducted without the addition of any lime: on the other hand, many persons hold that the addition of a small quantity of lime is essential to promote clarification.

If no lime is added, any sour juice that may be necessary may be run direct into the clarifier, and the process of heating the clarifier conducted in the ordinary way. If, on the other hand, lime is added, it would probably be preferable to add the sour juice to the clarified juice after it has run down on the battery. If lime is added the quantity used should be considerably less than in sugar-making, not more than 1 lb. to a 500-gallon clarifier and probably ½-lb. would be nearer the mark.

From experiments recently made in the laboratory, however, the writer is inclined to the opinion that if sour juice is added to the clarifier, the effect is to assist the coagulation of the albuminoids which rise to the surface in the normal way, and that the addition of a small amount of lime only serves the same purpose.

In these experiments quite as satisfactory clarification was secured by the use of cane juice in the above proportion as by the use of small quantities of lime.

An example of the effect of acidity in the coagulation of albuminoids is seen in sour cane juice in which the coagulated albuminoids rise to the surface in the form of the familiar black scum.

The question of lime or no lime seems to be open to discussion, and it constitutes a practical point which syrup makers must settle for themselves.

Once the acid liquor has been run down on to the battery, the operation of boiling is conducted on similar lines to those of sugar-making, with the important difference that a considerably increased degree of attention must be paid to cleaning the tayches during boiling. The operation of clarification conducted by either of the above methods, suffices only to remove a portion of the impurities, and the remainder must be got rid of by persistent cleaning on the copper wall. In addition to the ordinary wooden paddles commonly used for this operation in sugar houses, the use of skimmers constructed of perforated plate or stout trays of fine mesh wire-gauze seems desirable. On the success of this operation the appearance of the finished syrup will largely depend; hence too much stress cannot be laid on its importance.

The end of the operation is determined when the syrup has reached the required specific gravity. This is determined by testing the hot liquor by means of a hydrometer. The instrument commonly employed in syrup boiling is the Beaumé hydrometer.

As already pointed out, finished syrups should possess a density of not less than 40° Beaumé cold. This is secured in the operation of boiling by continuing the concentration until the hot liquid gives a reading of 35° Beaumé with the hydrometer, the difference between the hot and the cold reading being accounted for by contraction during cooling. The following tabular statement shows the approximate correspondence between the densities of hot and cold syrup:—

Density of finished syrup hot.	Density of cold syrup.
34° Beaumé	39° Beaumé
35° „	40° „
36° „	41° „
37° „	42° „

In this connexion a word may not be out of place with regard to hydrometers.

The possession of an accurately calibrated hydrometer is essential if syrup is to be made successfully. Hydrometers, especially those of inferior quality, are liable to considerable errors of instrument on this account, and it is very desirable that the calibration of hydrometers should be carefully checked by some competent authority. It may sometimes happen also that the scale becomes slightly shifted after the instrument has been in use for some time, possibly as the result of careless handling, and the readings thus caused to be erroneous. The best course is to obtain a good quality instrument from a reliable dealer in the first instance, to have the readings of this checked, and to ensure that reasonable care is exercised in the handling of the instrument, and that when it is not in use it is kept in a safe place.

As stated above, the Beaumé hydrometer is usually employed, but other forms can also be used, provided the equivalent readings are known. From a rational point of view, it is no doubt in many respects eminently desirable that a scale reading in degrees specific gravity should supersede the old fashioned Beaumé degrees.

For convenience of reference the following table shows the equivalent value of Beaumé degrees and specific gravity at 84° F. for the values likely to be encountered in syrup making :—

Specific Gravity.	Beaumé.
1·3211	35°
1·3340	36°
1·3458	37°
1·3585	38°
1·3719	39°
1·3848	40°
1·3986	41°
1·4125	42°

The main requirements of finished syrups have already been summarized in the early portion of this paper. It may be added that the general practice in Barbados appears to be to aim at producing an article of which the test is said to be the two forties, i.e. 40° Beaumé and 40° polarization, and this may certainly be regarded as a good practical standard.

A certain demand also exists for what is termed extra heavy fancy molasses: this is a syrup boiled to a slightly higher specific gravity than the ordinary article, namely 41° Beaumé instead of 40°, which commands a slightly higher price per gallon.

A point of some importance is that syrups should not contain any appreciable amount of iron, since the presence of it not only causes them to be dark in colour, but also gives rise to blackening of tea when mixed with it for sweetening purposes owing to combination of the iron with the tannin in the tea to form ink. This point can very well be tested by syrup makers for themselves from time to time.

No doubt the use of copper vessels for boiling syrup is to be preferred to those made of iron, since thereby the risk of contamination with iron is minimized, and the production of a good light-coloured syrup ensured.

The question of storage of finished syrups is also important and greater attention is required in this respect than is the case where muscovado sugar is being manufactured. When, as has sometimes been done, the syrups are run down into the wooden coolers—usually employed in sugar houses in the Leeward Islands for receiving muscovado massecuite—trouble has been not infrequently experienced owing to the starting of leakages in the wood and loss has resulted in consequence.

On this account concrete or stone coolers are greatly to be preferred for the reception of the hot liquid ; it is further very desirable that reservoirs of sufficient capacity should be provided into which the syrup can be run from the coolers and stored prior to running off into puncheons for shipment. The absence of such tanks renders more difficult the operation of blending to obtain a uniform product. They are best constructed of stone masonwork or concrete, and the interior should be faced with cement and free from cracks, since the presence of these latter affords room for harbouring bacterial and fungoid organisms likely to be detrimental to the stored syrup. They should be fitted with a satisfactory cover to prevent dust getting in and should preferably be provided with two cocks, one at the bottom and the other about 9 inches above the bottom of the reservoir. This allows room for any fine suspended dirt to settle at the bottom of the cistern and the clear supernatant liquid to be drawn off without disturbing it. Both of these cocks should be provided with locks. Every precaution should be taken to maintain tanks used for storing in good condition and before commencing crop they should be thoroughly overhauled and cleaned.

A word may be said as to packages for shipment of the product ; in this respect also careful attention is required. In Barbados, syrup is shipped in new puncheons, and this course seems to be a very sound policy. Not only do second-hand packages occasion risk of loss owing to their lack of strength, but an old puncheon is more likely to harbour dangerous organisms which may give rise to souring. Moreover, a sound well-coopered package seems likely to be more readily saleable than one of indifferent quality, irrespective of the merits of the contained syrup. As a measure of precaution likely to prevent contamination with dangerous bacteria, it is strongly recommended that all puncheons intended to contain syrup should if possible be cleaned out with a jet of live steam before being filled.

Before concluding, a few remarks may be made concerning the market for syrups.

During the past season (1913) the price for this class of product has been remarkably good, and has contrasted very favourably with the market value of muscovado sugar. With

better prices for sugar and larger crops, the position may become entirely altered.

At the present time the market for syrups is relatively small and is largely confined to Canada, where the bulk goes into direct consumption among the fishermen and lumbermen of that country, the balance being used in confectionary and as a sweet. A small amount is also consumed in the United States of America. The annual consumption in Canada is estimated at somewhere about 60,000 puncheons, and the market is increasing. In ordinary years the demand is fully met by the Barbados supply; it is only in abnormally unfavourable seasons such as the last that there is a shortage and a heavy demand for syrups at high prices.

The Barbados article constitutes the standard at the present time, and for syrups to be readily saleable they must conform fairly closely to this; any big increase in the output would probably lead to over-production and consequently a considerable drop in prices. At the same time the market is increasing, and it would seem wise policy for sugar planters who are compelled to grind their own canes to place themselves in a position to manufacture syrup in their works if at any time the condition of the market shows that it is profitable to do so.

It must, however, be remembered that, if the demand for syrups should be greatly augmented, it would probably be a simple matter for central sugar factories to turn their attention to the manufacture of syrups in place of sugar.

It seems clear, therefore, that the manufacture of syrups cannot be regarded as a satisfactory substitute for the introduction of the central factory system.

In conclusion, I have to acknowledge assistance rendered by Mr. V. M. Weil, B.Sc. in the performance of the analytical work alluded to in the course of this paper.

REPORT ON THE PREVALENCE OF SOME PESTS AND DISEASES IN THE WEST INDIES DURING 1912.

BY H. A. BALLOU, M. SC.,

Entomologist to the Imperial Department of Agriculture.

Two reports on the Prevalence of Insect Pests and Fungus Diseases in the West Indies have already appeared. The first of these, covering the period from April 1909 to June 1910, was published in the *West Indian Bulletin*, Vol. XI, pp. 73-106; the second, which covered two periods, A, July 1910 to March 1911, and B, April 1911 to December 1911, appeared in the *West Indian Bulletin*, Vol. XII, pp. 412-443.

The information presented in this report has been accumulated in the same way as that in both the previous ones: Blank forms have been sent out to the Agricultural Officers in each of the islands in the Windward and Leeward groups and these have been filled in under the several headings and returned.

In addition, however, the reports of visits during the year to several of these islands by the Entomologist and Mycologist have been consulted and certain information taken from them has been included. Further, reference has been made to returns received monthly from each of these islands, entitled Items of Departmental Interest, in which reference is made each month to any special condition relating to insect pests and fungus diseases.

The tabular arrangement used in the last previous report, showing the observations of occurrence and non-occurrence of the several pests and diseases is again made use of, as constituting an easy form of reference.

An additional feature is to be found in the summaries presented herewith which show the features of special interest in connexion with the occurrence of pests and diseases in each island.

Mr. F. W. South, the Mycologist to this Department, resigned his post in March 1913, to accept promotion under the Department of Agriculture, Federated Malay States, and as the post of Mycologist is vacant at the time this report is being prepared, that portion dealing with plant diseases as well as that concerning insect pests has been dealt with by the Entomologist.

PART 1.—INSECT PESTS.

Sugar-Cane.

MOTH BORER.

GRENADA. Reported on cane plot at Morne Rouge South several times in 1912.

ST. LUCIA. It was common, but no special damage was reported.

ANTIGUA. It was not a serious pest during the period under review. A perceptible decrease in numbers was observed from those of last year (1911).

ST. KITTS. This insect occurred in large numbers from April to July in old canes. This seems to have been due to the excessive drought, and in some districts to over ripeness of the canes.

NEVIS. It is found on every estate but is not considered to be the cause of much damage.

WEEVIL BORER.

ST. LUCIA. It occurred commonly but no special damage was reported.

ANTIGUA. It was prevalent in all cane fields.

ST. KITTS. Old canes were found badly attacked early in the year on one estate; and on another, canes damaged by rats were infested by this insect.

ROOT BORER.

ST. LUCIA. Recorded as being present: no serious attack reported.

ST. KITTS. A root borer occurred commonly on one estate where the Entomologist carried out investigations with regard to cane pests in the early part of the year (see p. 347).

TERMITES.

ST. KITTS. These insects again occurred in certain fields on the same estate where they were formerly recorded. This kind of injury does not seem to have spread to other estates. Termites were investigated and reported on by the Entomologist (see p. 347).

HARD-BACK GRUBS.

ANTIGUA. During the early part of the year these were fairly numerous. Not so noticeable during latter part.

ST. KITTS. The brown hard-back (*Lachnosterna patruelis*) was found in large numbers on one estate by the Entomologist (see p. 347).

NEVIS. These were found in many of the fields, but not doing any damage.

MISCELLANEOUS INSECTS.

The canes on one estate were infested with shot borer, where the attacks of rind fungus, and other fungus diseases were most severe. Grasshoppers are a great pest in many districts especially in dry localities. Flocks of guinea fowls are successfully kept for the purpose of controlling these insects.

COTTON.

COTTON WORM.

GRENADA. This insect did not occur in Grenada during 1912.

ST. VINCENT. A serious attack was experienced along southern windward coast district in October and November.

ST. LUCIA. No serious damage reported. Very small area (about 35 acres) planted in cotton in 1912.

MONTSERRAT. Attacks were very mild up to the end of November. The second growth, made in the months of November and December, was attacked very generally but no serious damage was done except to cotton of the small growers at the north of the island.

ANTIGUA. Repeated attacks of cotton worm were experienced throughout the growing season varying in severity as follows : August, slight ; September, more severe : October and November, very severe ; December as in September.

ST. KITTS. The insect was most abundant and severe in its attacks during the past season. Large amounts of both Paris green and London purple were used.

NEVIS. It occurred in great numbers throughout the island and did a considerable amount of damage to the crop. The most severe attacks were in October and November.

VIRGIN ISLANDS. Bad attacks were experienced in November and December.

BOLL WORM.

ANTIGUA. A few isolated instances of attack were noted during the year (see under visits of Entomologist p. 348).

COTTON STAINERS.

GRENADA. These insects were very scarce on the 1912-13 cotton. The stand-over Sea Island cotton in the south of the island was almost free from this attack, though usually badly attacked in former years. No explanation of this circumstance is known at present.

ST. VINCENT. They were not so numerous as in previous years.

ST. LUCIA. They were present, but not reported to be troublesome.

MONTSERRAT. Stainers appeared early (September) and attempts at control (by collecting) were necessary on most estates. It is generally believed in this island that, after November, collecting is not an efficient means of control, as the insects become too abundant. The stainers are the most serious menace to the cotton industry of Montserrat at the present time. Both the white marked stainer *(Dysdercus andreæ)* and the dark stainer *(D. delauneyi)* occur in Montserrat. The former was much the more abundant a few years ago, but at the present time the dark form is the more common.

ANTIGUA. They were extremely abundant during the latter part of the year.

ST. KITTS. Cotton stainers gave very little trouble until the cotton was maturing and then they became a serious pest. However, as cotton is generally kept for only one picking, they do not cause great injury except in the few instances where cotton is planted as a longer term crop.

NEVIS. These were fairly numerous towards the end of the crop.

VIRGIN ISLANDS. Sporadic attacks occurred in January, February and March on old cotton.

SCALE INSECTS.

GRENADA. Both the black and the white scales were found on cotton at Morne Rogue South in 1912. Attacks were severe on both plant and ratoon Marie Galante: slight on Sea Island. Mit Afifi and Abassi.

ST. VINCENT. These were not as prevalent as usual in the leeward district.

MONTSERRAT. Black scale very scarce.

ANTIGUA. Both black and white scales not infrequently found in fields of old cotton.

ST. KITTS. No trouble from these pests, as the cotton is turned in early.

NEVIS. The black scale occurred in a few fields.

VIRGIN ISLANDS. Here the insects are not known as serious pests. White scale occurs chiefly on native cotton.

FLOWER BUD MAGGOT.

MONTSERRAT. Reported on one estate on windward side of the island in November, but no serious damage done.

ANTIGUA. The first appearance of this insect for the season was recorded on December 29, but little damage was done to the crop.

LEAF BLISTER MITE.

GRENADA. This did not occur in Grenada during 1912.

ST. VINCENT. It was not the cause of much damage. It increased and spread considerably toward the close of the crop.

ST. LUCIA. It was fairly common.

MONTSERRAT. The injury to first crop cotton was slight. Second gr wth considerably interfered with on one estate. Late in the season it was very prevalent as usual. It was less abundant on those estates where great care is taken to destroy all the old cotton plants before planting the new crop.

ANTIGUA. One field was somewhat severely attacked in August. It occurred generally in fields of old cotton.

ST. KITTS. It was to be found in almost every field when the cotton was maturing; no damage was done as the cotton was pulled up and buried or burned.

NEVIS. It attacked severely the new growth put out after the vigorous attacks of cotton worm. Very little of it had been seen earlier in the season.

VIRGIN ISLANDS. It was present in nearly all districts especially so in the more dry situations.

MISCELLANEOUS.

GRENADA. A hard-back beetle *(Cyclocephala dimidiata)* appeared in numbers and cut away the petals of the opening flowers. Hand-picking was resorted to successfully.

ST. VINCENT. Referred to in connexion with Entomologist's visit in October. (See p. 349)

MONTSERRAT. Cotton aphis was reported as causing a considerable amount of injury to early planted cotton on one estate.

ANTIGUA. Aphis attacked a few fields during August and September.

NEVIS. Aphis was noticed in cotton fields in different parts of the island especially in the dry periods.

Cacao.

THRIPS.

GRENADA. There were no very severe attacks. As in previous years, these insects appeared in restricted dry or badly drained areas. In one valley on the west coast the attacks were more severe than elsewhere.

ST. VINCENT. They were not as prevalent as in previous years.

ST. LUCIA. Thrips were of general occurrence, but no serious attacks were reported.

DOMINICA. They were present, but in small numbers.

ST. KITTS. Cacao is cultivated only on one estate. Thrips occurred there in small numbers.

CACAO BEETLE.

GRENADA. As in former years the collection of this insect was a matter of estate routine on the dry, hot plantations of the west coast, and in a few cases on the windward side of the island. Its occurrence was about the same as in former years. One severe attack was noted on the west coast.

ST. LUCIA. Specimens of larvæ and pupæ of a beetle suspected of being the cacao beetle were submitted to the Entomologist for determination. Otherwise the cacao beetle is not known to occur in St. Lucia.

The specimens referred to probably belonged to one or more species of Leptostylus. (H.A.B.).

SCALE INSECTS AND MEALY BUGS.

GRENADA. These are rare. Slight attacks of mealy bug occurred in the neighbourhood of St. George's. A mealy bug regularly covered with sulphur-coloured wax was noted several times.

DOMINICA. These are usually present, but in small numbers.

ST. KITTS. Ants and mealy bugs occurred on cacao in large numbers : they seem to affect the flowering of the trees.

VIRGIN ISLANDS. Mealy bugs are somewhat prevalent in times of drought.

MISCELLANEOUS.

GRENADA. The green grass bug or shield back bug (*Nezara viridula*) attacked cacao pods in southern district, rather severely on a small area.

NEVIS. On one estate, the young pods were attacked by aphis to such an extent that development was checked and they withered and turned black.

Limes and Other Citrus Plants.

SCALE INSECTS.

GRENADA. Black scale occurred on Morne Rouge limes. Attacks were not universal on this area, but two or three young lime trees suffered severely.

ST. VINCENT. These are still bad, especially *Coccus* [Lecanium] *viridus.*

ST. LUCIA. All the commoner scales occurred generally throughout the lime growing area but there were no serious attacks. The green and the snow scales were the most troublesome.

DOMINICA. Scale insects, generally, have been well under control during the year. At one or two places somewhat severe outbreaks were reported towards the end of the dry season.

MONTSERRAT. The principal scale—the purple scale—has been more prevalent on limes than usual. A few fields have suffered, and in one the majority of the trees have been killed. There seems to be a decrease in the numbers of the green scale. A few trees have been observed to be severely attacked by the West Indian red scale. This is the first time that this scale has been recorded as a serious pest of limes. The lantana bug is very scarce.

ANTIGUA. These were common in all lime fields. Green scale was especially common on young shoots and in fields of young trees. Snow scale occurred on stems and branches of older trees. Purple scale and West Indian red scale were also common. There was a somewhat appreciable increase in the numbers of scale insects in the early part of the year, and a decrease as the season advanced.

ST. KITTS. There is practically no lime cultivation now in St. Kitts. Scale insects are abundant where there are lime trees.

NEVIS. Green, purple and snow scales occurred on limes. In one field fairly large trees were killed partly by the purple and the snow scales and partly by drought.

VIRGIN ISLANDS. White scale was abundant : purple scale less so.

BARK BORER.

No observations.

TWIG BORER.

ANTIGUA. Severe attacks of this insect experienced on one lime estate during September and October. From this time, severity of the attack decreased. The outbreak was most serious in the southern part of the island, but evidences of the occurrence of the pest were found in other localities where limes are grown.

FRUIT FLY.

DOMINICA. Attacks were not so general as in former years.

Rubber.

SCALE INSECTS.

DOMINICA. No complaints have been received of disease attacking any of the many thousands of Para rubber plants sent out during recent years from the Station.

ST. KITTS. The scale insects on the rubber trees on one estate were less abundant than formerly. Rubber is not grown on a commercial scale in St. Kitts.

Sweet Potatoes.

SCARABEE.

GRENADA. This was recorded in the southern districts.

ANTIGUA. On the whole the crop has been free from this pest.

ST. KITTS. No attack of this pest reported.

CATERPILLARS.

ANTIGUA. These were fairly common during the latter part of the year, but did no serious damage.

ST. KITTS. No occurrence of this pest.

VIRGIN ISLANDS. There were bad attacks of caterpillars in November and December at Virgin Gorda.

RED SPIDER.

ST. LUCIA. Red spider was common in the drier districts.

ANTIGUA. A few isolated attacks occurred.

NEVIS. It was found in a field in small numbers.

MISCELLANEOUS.

GRENADA. A white fly, name unknown, noted on potatoes occasionally.

MONTSERRAT. Potato vines were attacked by slugs.

Yams.

SCALE INSECTS.

GRENADA. *Aspidiotus hartii* observed several times on the tubers.

ST. KITTS. The only trouble with yams was the scale that occurs on the tubers, in storage.

Green Dressings.

DOMINICA. *Canavalia ensiformis*, *Tephrosia candida* and *T. purpurea* have been remarkably free from all pests during the year. Pigeon peas were rather severely attacked by the weevil.

MONTSERRAT. Horse beans were attacked by a caterpillar on one estate during December, but the adult was not successfully reared. The caterpillar is similar to that known as the Bengal bean worm; if the same, it is less destructive on horse beans than on Bengal beans.

ANTIGUA. Several somewhat severe attacks were experienced during the year, but these were less serious than in some former years. Cowpeas were attacked by a caterpillar which burrowed into the stems from the tips. Visit of Entomologist. (see p. 348) Barbuda beans were attacked by aphis.

ST. KITTS. All green dressings were attacked by worm, including horse bean, in some instances.

GROUND NUTS.

MISCELLANEOUS.

ST. VINCENT. Green bug did a good deal of damage on one plantation.

NEVIS. A caterpillar was observed cutting into the buds, but the attack was slight.

ONIONS.

CATERPILLARS.

ANTIGUA. Common throughout growing season; they were easily controlled and did but little damage.

NEVIS. A slight attack of caterpillars was controlled by hand-picking.

GUINEA CORN.

MONTSERRAT. The ripening heads of guinea corn were attacked by the larvae of a small moth. A considerable amount of loss was caused in this way.

INDIAN CORN.

CORN EAR WORM.

ST. VINCENT. It was rather more noticeable than usual.

ANTIGUA. The pest was fairly common, but it was not regarded as being responsible for much damage.

ST. KITTS. It was very abundant and did much damage to the crop.

NEVIS. It was found in many fields, and a considerable amount of damage was done in some places.

VIRGIN ISLANDS. It was abundant in November and December.

HARD-BACK GRUBS.

ANTIGUA. They were common in heavy land: the amount of damage done by this pest is probably not fully realized.

ST. KITTS. They were not noticed as a pest.

COCO-NUTS.

WEEVIL.

ST. VINCENT. There were a few slight attacks by this pest.

WHITE FLY.

ST. VINCENT. It was fairly prevalent at the beginning of the year, but the attacks lessened in severity later.

DOMINICA. The coco-nut trees in Dominica continue to remain in excellent health.

SCALE INSECTS.

GRENADA. Coco-nut snow scale, glassy star scale, Bourbon aspidiotus, coco-nut mealy bug and green scale noted commonly.

ST. VINCENT. *Aspidiotus destructor* was rather bad on some estates.

ST. LUCIA. *Aspidiotus destructor* occurred on leaves and fruit, *Diaspis boisduvallii* on fruits. Numerous cast pupa-cases of lady birds were observed on infested fruits. No bad attacks were reported.

ANTIGUA. These were common, especially *A. destructor*.

ST. KITTS. They were commonly observed on the leaves, but no damage appeared to be done.

NEVIS. These were found chiefly on the older leaves and did not cause any damage.

VIRGIN ISLANDS. White scale (*A. destructor*) rather troublesome in some districts, especially on young trees.

MISCELLANEOUS.

GRENADA. Stem beetles have been noted once or twice.

NEVIS. Termites on coco-nut trees were fairly common but no damage seemed to be done.

GENERAL REMARKS.

ST. LUCIA. Cabbage caterpillars were very troublesome on cabbages grown between April and November. Red spider occurred on grape vines in dry situations.

PART II.—FUNGUS DISEASES.

Sugar-Cane.

ROOT DISEASE.

GRENADA. It destroyed canes of the Bourbon type at Morn Rouge South in December. Same variety of cane attacked at Westerhall.

ST. LUCIA. It was fairly common in some localities.

MONTSERRAT. Root disease was reported as being particularly bad on one estate, attacking Bourbon canes so severely that the owner decided to abandon this variety.

ANTIGUA. It was extremely common, especially on ratoon canes.

NEVIS. It was observed on several estates especially during the dry season.

RIND DISEASE.

ST. LUCIA. It was fairly common.

ANTIGUA. It was common throughout the island, appearing on canes that had been cut for a few days.

ST. KITTS. This disease was met with on many estates in different parts of the island. It seemed to be largely due to over-ripeness of the canes and to the attacks of moth-borer. Mr. South paid a special visit to St. Kitts in connexion with the occurrence of this disease.

RED ROT DISEASE.

ANTIGUA. It was found in isolated instances.

ST. KITTS. This disease was also found on one estate on over-ripe canes. It does not seem likely that it will become troublesome during the coming season.

PINE-APPLE DISEASE.

ANTIGUA It was not common.

ST. KITTS. Instances of cane plants dying off were reported, which in many cases were thought to be due to this disease.

MISCELLANEOUS FUNGI.

ANTIGUA. An unknown leaf disease was found in a few fields.

ST. KITTS. Canes attacked by rind fungus and other diseases, were infested by shot borer.

COTTON.

BACTERIAL BOLL DISEASE.

BLACK ARM.

ANGULAR LEAF SPOT.

GRENADA. The bolls of all varieties were attacked.

ST. VINCENT. These diseases (together with mildew) caused much loss of cotton, on account of the very wet ripening season. The bacterial boll disease and mildew were responsible for most of the damage done.

MONTSERRAT. Angular leaf spot was not prevalent during the season. It was markedly absent on one estate where it had been abundant in the previous year. Nothing is known of the conditions which favour the spread of this disease.

ST. KITTS. Very few fields were affected by these diseases. There was an instance of bolls becoming black, but that seemed to be due to excessive rainfall.

NEVIS. Angular leaf spot found in a few fields, but not causing much damage.

WEST INDIAN LEAF MILDEW.

GRENADA. Not noted. This has probably not yet occurred in Grenada.

ST VINCENT.

ANTIGUA. It was common in fields of old cotton.

ST. KITTS. Very little of this disease was seen in the dry districts: it occurred in one district where the rainfall was heavy.

NEVIS. Fairly abundant in some localities after heavy rains in November, causing the shedding of leaves to a great extent.

Cacao.

ROOT DISEASE.

GRENADA. It is common all over the island, in cacao growing near streams. There was no outbreak during the season under review.

ST. LUCIA. It is general throughout the island, especially in the Dennery and Soufriére districts.

DOMINICA. There was no serious outbreak reported during the year. Trees in unfavourable situations continued to die from it from time to time.

CANKER.

GRENADA.. No severe cases noted. On several estates planters practise the cutting out of diseased bark.

ST. LUCIA. There was no serious attack, although the disease was common throughout the island.

DOMINICA. Experience confirms the view that the delicate varieties are very subject to canker. A few cases were observed of canker on the Forastero variety growing in heavy soils.

ST KITTS. A few trees were found affected on one estate.

DIE BACK.

GRENADA. This disease has not been differentiated locally from Phytophthora.

ST. LUCIA. It is of general occurrence ; common in some districts.

DOMINICA. There was no serious outbreak during the year.

BROWN ROT OF PODS.

GRENADA. This occurred to a slight extent in all parts of the island.

ST. VINCENT. It was not very prevalent.

ST. LUCIA. It was general in its occurrence but was severe in only two districts, Soufrière and Choiseul.

DOMINICA. It is always present on cacao estates in small quantity.

BLACK ROT OF PODS.

GRENADA. There were slight attacks all over the island.

ST. VINCENT. It occurred on all plantations.

ST. LUCIA. It occurs to the same extent as the brown rot.

DOMINICA. As for brown rot.

PINK DISEASE.

DOMINICA. Not reported during the year.

MONTSERRAT. This disease is very common on the Experiment Plot at Harris'.

THREAD BLIGHTS.

No observations recorded.

HORSE HAIR BLIGHTS.

GRENADA. It was noticed in one instance in proximity to the forest areas of St. Andrew.

MISCELLANEOUS.

ST. LUCIA. The loss of *Erythrina* sp. (? *indica*) used as shade on some estates continues. This is due to an undetermined disease and where it occurs this species is being dug up and replaced with *E. velutina* or *E. umbrosa*.

ST. KITTS. A few cacao trees died suddenly and though this was attributed to soil inhabiting grubs, no specimens of these could be found.

LIMES.

ROOT DISEASES.

DOMINICA. These were fairly general on weak and neglected lime trees. An outbreak on one estate was investigated by the Mycologist in May.

MONTSERRAT. Root disease is believed to exist in Montserrat very generally, but the brackets of Fomes are difficult to find even in fields where trees have been killed by the disease.

ANTIGUA. These are not increasing.

BLACK ROOT DISEASE.

ST. LUCIA. In the case of all four trees infected with this disease the results were fatal.

DOMINICA. It was not so prevalent as in former years; this may have been due to favourable weather conditions.

RED ROOT DISEASE.

DOMINICA. There were serious outbreaks of this disease on one estate in particular, and there were several isolated cases in other localities.

ST. LUCIA. A disease of lime seedlings occurred at Union, the Botanic Station and on light sandy soil in those parts of the island usually considered dry. This disease is very destructive and spreads rapidly in wet weather.

RUBBER.

BLACK ROOT DISEASE.

GRENADA. Several young trees were killed by this at the Grand Etang forest plot.

SWEET POTATO.

ROOT DISEASE.

No observations.

YAMS.

TUBER DISEASE.

No observations.

GROUND NUTS.

ROOT DISEASE.

GRENADA. It was common all over the island; one bad attack reported in 1912.

LEAF RUST.

ST. VINCENT. It was observed in one or two fields.

MONTSERRAT. It was very common as usual.

ANTIGUA. Noticed on mature plants in experiment plots.

ONIONS.

BACTERIAL ROT.

ANTIGUA. It was not noticed in the field.

ST. KITTS. This rot only attacks the onions after they are harvested.

IMPHEE.

ROOT DISEASE.

No observations.

GUINEA CORN.

ROOT DISEASE.

No observations.

INDIAN CORN.

ROOT DISEASE.

ANTIGUA. Sporadic attacks recorded, but this disease was not so serious as in former years.

COCO-NUTS.

BUD ROT.

GRENADA. Some thirty-five trees suspected to be attacked by bud rot were cut down and destroyed in various parts of the island.

ST. VINCENT. A few cases of this were observed.

ANTIGUA. No definite instance of this has been found in Antigua.

ROOT DISEASE.

ST. VINCENT. One case of this was observed.

MISCELLANEOUS.

An unknown stem rot (canker) has been noted fairly frequently in the southern districts.

MISCELLANEOUS NOTES.

LOVE VINE AND MISTLETOE.

GRENADA. Love vine is still prevalent in hedges, but the new law will probably have the effect of decreasing the frequency of its occurrence. Mistletoe is still bad in the mountain districts on cacao. Its destruction has become part of the estate routine on the better managed properties.

ST. LUCIA. Love vine is becoming very common and spreading to a serious extent. In one instance limes in the Castries district were very badly attacked. Mistletoe is common on some lime estates and a serious pest in certain instances in the Castries district.

DOMINICA. Dominica, on the whole, remains in a satisfactory condition with regard to serious outbreaks of fungi and insect pests. Love vine has been rather more in evidence than last year, and has been reported from new localities. No effort is spared to impress upon planters the importance of keeping this serious parasite in check.

There is still a fair amount of mistletoe to be seen in certain districts in the island, but the planters now take active measures to keep their estates as free as possible from this parasite.

ANTIGUA. Love vine is probably increasing slightly, the rate of increase during the year being less than in the previous one.

ST. KITTS. In some parts of the island, love vine is to be seen ; it does not occur on valuable trees.

NEVIS. Love vine was observed on hedges along the roadside but not on any cultivated fields.

VIRGIN ISLANDS. Love vine and mistletoe are fairly common.

Parasites of Injurious Insects.

GRENADA. Cephalosporium has done good work on the mango shield scale. Sphaerostilbe has increased rapidly in the St. David's district.

ST. VINCENT. The cotton worm was parasitized to a noticeable extent by *Chalcis* sp. toward the end of the year. The Jack Spaniard has again been useful in preying extensively on the cotton worm. Many planters are encouraging these beneficial insects by erecting rough shelters as nesting places for them in or near the cotton fields.

ST. LUCIA. Parasite of scales on lime trees. The white headed fungus was of more general occurrence. In some districts (Canaries and Soufrière) it was exceedingly abundant, in some localities, being found on every scale infested leaf. The black-headed and the red-headed fungi were general throughout the island. The buff shield-scale fungus was not so general but was well established in some districts (Castries and Soufrière).

ANTIGUA. Parasitic fungi on scale insects are much more common than was realized some time ago. Lady birds are increasing in numbers on some lime plantations.

ST.KITTS. Attempts to introduce fungus parasites on scale insects have so far not succeeded. The Jack Spaniard is a useful ally in destroying the cotton worm.

VIRGIN ISLANDS. *Cephalosporium lecanii* was noticed in the Experiment Station by Mr. Tempany during his visit in November 1912.

NEVIS. The cotton worm was extensively parasitized by a hymenopterous insect (*Chalcis* sp.). In one instance at least 75 per cent. pupae were parasitized.

Climate.

ST. VINCENT. Dry during earlier part of the year and very wet during latter part.

ST. LUCIA. The rainfall for the island was somewhat below the average, though not so low as in some years previous to 1910. Shortage of rain was chiefly felt between April and July. Average rainfall at twenty-six stations : 73·13 inches.

DOMINICA. During the year the weather conditions have been most favourable in checking the root troubles which have been prevalent in the island during the last few years. The rainfall was considerably lower than the average for the last twenty years and much less than the rainfall recorded during the last four or five years.

MONTSERRAT. A severe drought prevailed up till end of September after which the rainfall was normal.

ANTIGUA. Severe drought experienced during year, the rainfall being much below the average.

ST. KITTS. The season of 1912, especially for the cane crop, was an abnormal one. An excessive drought prevailed in the early part of the year and then owing to Central Factory being late in starting and to labour troubles afterwards, the canes in many cases were over-ripe, and easily yielded to diseases and pests. The rainfall during the year was 42·57 inches. Of this only 14·76 fell in the first seven months and this severe drought was responsible in a great measure for the number of pests attacking the cane crop.

VIRGIN ISLANDS. Rainfall very short down to October, then torrential rains. Total rainfall for year (January to December) 46·41 inches. Average for previous eleven years 53·73 inches.

NEVIS. The rainfall for the year was below the average and 6 inches below that of the previous year. A severe drought was experienced from June to September, and planters found great difficulty in getting crops established.

VISITS OF THE ENTOMOLOGIST IN 1912.

The Entomologist visited St. Kitts, Nevis, Antigua and Montserrat during the months of April, May and June: St. Vincent in October, and Antigua in December.

In St. Kitts, sugar-cane pests were the principal objects of study. Of these the most important were the termites or white ants, the moth borer, hard-back grubs, and the weevil borer. The root borer, the shot borer and grasshoppers were also observed and reported upon.

Scale insects on limes were reported upon with special reference to one estate where the cultivation of limes was being tried. The conclusion was arrived at that the soil and other conditions were such as to render the fields on this estate quite unsuitable for these trees which were in consequence very weak and severely attacked by scale insects.

On another estate, where cacao is grown, ants and mealy bugs were found in numbers on the cacao trees. The mealy bugs

protected by the ants, infested the flower cushions, eriously interfering with the development of flowers.

With reference to the insect pests of sugar-cane, it may be mentioned that the fields of a certain group of estates comprise the only locality where severe attacks of termites on growing and ripening canes are recorded. Somewhat similar attacks are known in British Guiana (see *Agricultural News*, Vol. XII p. 282).

The small brown hard-back *Lachnosterna patruelis* was recorded as an inhabitant of the soil of sugar-cane fields for the first time, and for the first time also the root borer grub was suspected of being related to the greyish-brown weevil (*Exophthalmus esuriens*).

Cotton stainers and the leaf-blister mite of cotton were under observation during this visit to St. Kitts, but they were not particularly abundant.

In Nevis, the scale insects attacking limes on one estate were observed and reported upon. Coco-nuts were exceptionally healthy and there were no special attacks noted of insect pests of sugar-cane.

In Antigua, the grubs of one or more species of hard-back beetle in the soil of cane fields were studied. Very little definite information with regard to these insects is available. An unidentified species of Lachnosterna is known to occur in Antigua and it is believed that the larva of this insect is the one which causes the injury to newly planted cane cuttings and to the roots of older canes.

Termites also frequently seriously interfere with the growth of the plants, making it necessary to supply several times in order to ensure a complete stand.

The weevil, *Exophthalmus esuriens*, was also found in Antigua on pigeon pea trees along the borders of cane fields. No root borer grubs were found on this occasion, but they had previously been observed in Antigua and it is likely that they were the larvae of this species of insect.

An interesting point noted in connexion with sweet potatoes growing at Skerretts Station was that although the plants were suffering from drought, they were free from red spider and thrips which often attack sweet potatoes in dry weather.

The visit to Montserrat was largely devoted to a study of the condition of the limes in that island. The green, white and purple scales were all recorded.

The visit to Antigua in December was made in consequence of an attack of a twig borer of limes which made its appearance earlier in the year and seemed likely to develop into a serious pest. This insect has been identified as *Elaphidion mite*. Energetic measures quickly reduced its numbers. Its habits seem to render it liable to fairly easy control.

During this visit, the flower bud maggot of cotton was not to be found, its first appearance for the season being recorded a few days later (December 29).

Corn and cotton were both attacked by the cotton boll worm (*Heliothis obsoleta*) and sweet potatoes by the larvae of a butterfly.

Limes in different parts of the island were seriously affected by the California red scale (*Chrysomphalus aurantii)* and the attacks of this insect in connexion with the serious drought that had been experienced in Antigua had caused the death of many trees.

During his visit to St. Vincent in October, the Entomologist investigated the insect pests of coco-nuts, cotton and limes, and made observations on miscellaneous insects of general interest. Field notes were made of certain diseased conditions of coco-nut trees together with specimens and photographs of these trees. A memorandum was prepared on this subject in which the Mycologist stated that bud-rot, root disease and a leaf disease occurred on the trees examined by the Entomologist.

The insects attacking the coco-nut trees in St. Vincent were the palm weevil, two species of white fly and scale insects. Cotton was attacked by the cotton worm (a very unusual occurrence in St. Vincent) and this insect was extensively preyed upon by the Jack Spaniard (*Polistes annularis*) and later was parasitized by a small hymenopterous insect (*Chalcis* sp.). Leaf blister mite was remarkably scarce. Black scale was fairly abundant. Earlier in the season young cotton plants had been attacked by a small bronze beetle, but at the time of this visit they were very scarce. The young buds of cotton were attacked by a bug, *Edessa meditabunda*, which caused the buds to drop off. Another bug belonging to a different family was found on the cotton and this may affect the buds in the same way.

Thrips on cacao were found to be much less abundant than they had been in previous years.

Arrowroot was attacked by the ordinary arrowroot worm (*Calpodes ethlius*).

Limes in St. Vincent are very subject to attacks by scale insects and these were found wherever limes were examined.

The bug (*Edessa meditabunda*) mentioned as attacking cotton was a serious pest on ground nuts on one estate.

Cassava at the Agricultural School was attacked by a large thrips.

VISITS OF THE MYCOLOGIST IN 1912.

During 1912 Mr. South made visits as follows :—To St. Lucia in April, to Dominica and St. Kitts in June. In returning from St. Kitts the opportunity was taken to go ashore at Antigua, Dominica and St. Lucia.

In St. Lucia the diseases investigated were those of bananas, cacao, limes, sugar-cane and immortel (*Erythrina* sp.).

In connexion with bananas there were three diseases noted ; the disease *Marasmius semiustus* and two others of which only incomplete information is as yet available. These latter are designated in the report on them as Banana Disease No. 1 and Banana Disease No. 2.

The cacao diseases investigated were die back, root disease black pod (Phytophthora), and the red or Koselinia root disease which latter formed the subject of a special report.

The collar and stem canker of limes and a canker of immorted which causes the death of many shade trees in cacao cultivations were also studied.

Sugar-cane cultivations were visited and the root disease (*Marasmius sacchari*) was reported upon.

In Dominica the red root disease of limes was the subject of investigation and report.

The visit to St. Kitts was occasioned by the discovery of the rind disease of sugar cane attacking the variety B. 147 which previously had been thought to be immune to this disease. During this visit observations on the root disease of canes were also made and certain diseased conditions of limes were studied and reported upon. Following on the discovery of this occurrence of the rind fungus in St Kitts in 1912, experiments were started in St. Kitts by Mr. W. R. Dunlop, and in Barbados by the Mycologist as to the manner of infection by this fungus. The following note, taken from the *Agricultural News*. on the result of these experiments is of interest in this connexion.

Rind Disease. (*Colletotrichum falcatum.*)

The fungus which causes rind disease (red rot) is a facultative wound parasite, of which the degree of virulence varies greatly according to climatic conditions, age and particularly with the variety of cane. In the case of the ordinary sporadic outbreaks in the West Indies, its chief harm probably lies in its invert action on cane sugar, thereby tending to increase the glucose ratio in the factory, though under certain exceptional conditions its harmfulness may be felt through a reduction in the yield of cane per acre. The chief mode of infection seems to be through the agency of boring insects, or through wounds caused by other means. In these experiments the disease was not communicated by infected cuttings, a result which agrees with that obtained in America. It appears that the presence of the fungus in the cane cutting induces the developing bud to separate its organic connexion with the cutting by the formation of a cork layer. The Bourbon variety is least vigorous in this particular respect. The chief danger in planting infected cuttings would appear to lie in the fact that the soil becomes infected, thereby increasing the chance of the disease being communicated by root borers and other grubs attacking the sugar-cane in these islands. It is evident that in regard to the communication of the disease by cuttings, the behaviour of *C. falcatum* in the West Indies is different to that of the organism in the eastern Tropics. (See *Agricultural News*, Vol. XII, Nos. 286, 287 and 288.)

SPECIAL FEATURES OF THE YEAR 1912.

Insect Pests.

GRENADA. The non-occurrence of the cotton worm in Grenada in 1912 is a fact of special interest. This insect has occurred in Grenada each year since the revival of the cotton industry in that island. This would indicate that the natural enemies of this insect exercised an unusually strong controlling

influence over it or that natural conditions were extremely unfavourable to its development.

It is recorded that cotton stainers attacked the young cotton but not the older plants. This is the reverse of the usual condition, the old cotton generally being somewhat severely attacked while the young plants are but little affected, if any.

The leaf blister mite which has occurred in every previous year was reported as not occurring in 1912.

A small beetle *Cyclocephala dimidiata* attacked the flowers of cotton.

Cacao pods were attacked by green bug (*Nezara viridula*). This is a record of a new pest on cacao and a new food plant for this insect.

ST. VINCENT. The cotton worm was extremely abundant in the southern portion of the island. This is only the second occasion during the past ten years on which it has been necessary to resort to the use of poisons to control this insect in St. Vincent; in other years it has been controlled by its natural enemies, chiefly the Jack Spaniard and one or more species of Chalcis flies. These latter were unusually abundant toward the end of the year. This attack of the cotton worm which was much more severe than the only previous one in 1907 is of interest as coming in the same season when this insect did not occur in Grenada.

Scale insects on limes continued to be abundant, the green scale (*Coccus viridis*) especially so.

The attacks of the bug *Edessa meditabunda*, on ground nuts and cotton flower buds is also a feature of special interest.

MONTSERRAT. The increase in the numbers of the cotton stainers towards the end of the year and especially the change in the relative numbers of the two species are of interest. Formerly *Dysdercus andreae* was much the more abundant, individuals of *D. delauneyi* being only occasionally seen. During 1912, the latter species was noted to be much more abundant in all parts of the island than the former.

The occurrence of the West Indian red scale (*Selenaspidus articulatus*) in sufficient numbers to cause serious injury to limes is unusual: this insect is generally to be found, but in small numbers.

ANTIGUA. In Antigua the most prominent insect pest for the year was the lime twig borer (*Elaphidion mite*) which appeared as a pest of considerable importance at first sight, but a study of its mode of attack led to the conclusion that it can be controlled without great difficulty or much expense.

The California red scale, in connexion with the extreme drought caused the death of many lime trees.

ST. KITTS. The brown hard-back and the root borer of canes were reported in St. Kitts in 1912 for the first time.

The cotton worm, the corn ear worm and the caterpillars attacking the green dressing crops were all abundant.

Shot borer occurred in connexion with the rind fungus at the north end of the island.

SPECIAL FEATURES OF THE YEAR 1912.

Fungus Diseases and Beneficial Fungi.

GRENADA. The bacterial boll disease was unusually severe on cotton.

The West Indian leaf mildew did not occur. This is of interest in connexion with the fact that in the later part of the year cotton in St. Vincent suffered severely from attacks of this fungus.

The bud-rot of coco-nuts was suspected and a number of trees were cut down and destroyed.

The beneficial fungi, the shield scale fungus (*Cephalosporium lecanii*) and the red-headed fungus (*Sphaerostilbe coccophila*) made satisfactory progress during the year.

ST. VINCENT. Bud-rot and root disease of coco-nuts were discovered in St. Vincent during 1912, and the black-pod disease of cacao was more abundant than usual.

ST. KITTS. After a lapse of several years, the rind fungus and the red rot disease again appeared in St. Kitts.

It is remarkable that the rind disease should have in this instance badly attacked the variety B. 147, which has hitherto been considered especially resistant to this disease.

TABLES TO SHOW THE OCCURRENCE OF PESTS AND DISEASES OF CROPS IN THE WINDWARD AND LEEWARD ISLANDS.

FOR THE YEAR JANUARY TO DECEMBER 1912.

Explanation :—

+	=	positive observation of occurrence.
O	=	definite „ „ non-occurrence.
?	=	doubtful „ „ occurrence.

Where a blank space is left, no reliable information under this head has been received.

INSECT PESTS.

	Grenada.	St. Vincent.	St. Lucia.	Dominica.	Montserrat.	Antigua.	St. Kitts.	Nevis.	Virgin Islands.
CACAO.									
Thrips (*Heliothrips* [Physopus] *rubrocinctus*, Giard)	+	+	+	+			+		
Beetle (*Steirastoma depressum*, L.) ...	+		?	O			O		
Scale Insects and mealy bugs	+			+			+		+
Miscellaneous	+						+	+	
COCO-NUTS.									
Weevil (*Rhynchophorus palmarum*, L.)		+							
White fly (*Aleyrodicus cocois*, Curtis)		+							
Scale Insects	+	+	+			+	+	+	+
Miscellaneous	+							+	
CORN (INDIAN).									
Corn ear worm (*Heliothis obsoleta* Hübn.) and (*Laphygma frugiperda*, S. and A.)		+				+	+	+	+
Hard back grubs						+			
CORN (GUINEA).									
Caterpillars					+				

INSECT PESTS.—(*Continued.*)

	Grenada.	St. Vincent.	St. Lucia.	Dominica.	Montserrat.	Antigua.	St. Kitts.	Nevis.	Virgin Islands.
COTTON.									
Cotton Worm (*Alabama argillacea*, Hübn.)	O	+	+		+	+	+	+	+
Boll Worm (*Heliothis obsoleta*, Hübn.) and (*Laphygma frugiperda*, S. and A.)						+	O		
Cotton Stainers (*Dysdercus andreae*, L.) and (*D. delauneyi*, Leth.)	+	+	+		+	+	+	+	+
Scale Insects (*Saissetia nigra*, Neitn.) and (*Hemichionaspis minor*, Mask.)	+	+				+	?	+	+
Flower-bud Maggot (*Contarinia gossypii*, Felt.)					+	+			
Leaf-blister Mite (*Eriophyes gossypii*, Banks)	O	+	+		+	+	+	+	+
Miscellaneous	+	+			+	+		+	
GREEN DRESSINGS.									
Leaf-eating Caterpillars...				+	+	+			
GROUND NUTS.									
Mealy-bugs									
Miscellaneous		+						+	
LIMES AND OTHER CITRUS TREES.									
Scale Insects	+	+	+	+	+	+	+	+	+
Bark Borer (*Leptostylus praemorsus*, Fabr.)			+						
Twig Borer (*Elaphidion mite*, Newm.)						+			
Fruit Fly				+					
Miscellaneous			+						
ONIONS.									
Caterpillars						+		+	
RUBBER.									
Scale Insects							+		

INSECT PESTS.—(*Concluded.*)

	Grenada.	St. Vincent.	St. Lucia.	Dominica.	Montserrat.	Antigua.	St. Kitts.	Nevis.	Virgin Islands.
SUGAR-CANE.									
Moth Borer (*Diatraea saccharalis*, Fabr.)	+		+			+	+	+	
Weevil Borer (*Sphenophorus sericeus*, Oliv.)			+			+	+		
Root Borer (?*Exophthalmus esuriens*) ...			+				+		
Cane Fly (*Delphax saccharivora*, Westw.)							O		
White Ant (Termites)							+		
Hard-back Grubs (*Lachnosterna* spp.)...						+	+	+	
Scale Insects and Mealy Bug									
Miscellaneous							+		
SWEET POTATO.									
Caterpillars (*Protoparce cingulata*, Fabr.) and others						+			+
Scarabee (*Cryptorhynchus batatae*, Waterhouse)	+					?		+	
Red Spider (*Tetranychus telarius*, L.)			+			+			
Thrips									
Miscellaneous	+								
YAMS.									
Scale Insects on tubers	+						+		
Love Vine, Mistletoe, etc.	+		+	+		+	+	+	+
Natural Enemies of Insect Pests ...	+	+	+			+	+	+	+
General Remarks and Notes on Climate, etc.		+	+	+	+	+	+	+	+

FUNGUS DISEASES.

	Grenada.	St. Vincent.	St. Lucia.	Dominica	Montserrat.	Antigua.	St. Kitts.	Nevis.	Virgin Islands.
BANANA.									
Marasmius semiustus and others ...			+						
CACAO.									
Root Disease	+		+	+					
Canker (*Phytophthora Faberi*, Maubl.)	+		+	+			+		
Die-back and Stem Disease (*Thyridaria tarda*, Bancroft)	?		+	?					
Brown Rot of Pods (*T. tarda*, Bancroft.)	+	+	+	+					
Black Rot of Pods (*P. Faberi*, Maubl.)	+	+	+	+					
Pink Disease (*Corticium lilacino-fuscum*, B. & C.)					+				
Thread blights									
Horse hair blights (*Marasmius equicrinus*, Muller)	+								
Miscellaneous			+						
COCO-NUTS.									
Bud Rot	?	+							
Root Disease		+							
Miscellaneous	+								
CORN (INDIAN).									
Root Disease						+			
COTTON.									
Anthracnose (*Colletotrichum gossypii*, Southw.)									
Bacterial Boll Disease Angular Leaf Spot Black Arm	+	+			?		?	+	
West Indian Leaf Mildew	O	+				+	+	+	
GROUND NUTS.									
Root Disease	+								
Leaf Rust (*Uredo arachidis*, Lagl.) ...		+			+	+			
Leaf Spot (*Cercospora personata*, Ellis)									
Miscellaneous	+								

FUNGUS DISEASES.—(*Concluded.*)

	Grenada.	St. Vincent.	St. Lucia.	Dominica.	Montserrat.	Antigua.	St. Kitts.	Nevis.	Virgin Islands.
LIMES AND OTHER CITRUS TREES.									
Collar and Stem Canker			+						
Root diseases (? *Fomes lucidus*)				+	+	+			
Black Root Disease (*Rosellinia* sp.) ...			+	+					
Red Root Disease (*Sphaerostilbe* sp.) ...				+					
Miscellaneous			+						
ONIONS.									
Bacterial Rot							?		
RUBBER.									
Black Root Disease (*Rosellinia* sp.) ...	+								
SUGAR-CANE.									
Root Disease (*Marasmius sacchari*, Wakker)	+		+		+	+	+	+	+
Rind Disease (*Melanconium sacchari*, Massee)			+			+	+		
Red Rot (*Colletotrichum falcatum*, Went)						+	+		
Pine-apple Disease						?	?		
Miscellaneous						+	+		
Miscellaneous Notes (Disease of Immortel)			+						

RECENT TRIALS WITH COTTON IN GRENADA.

BY GILBERT AUCHINLECK, B.Sc., F.C.S.,

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In recent years there has been a revival of interest in the question of cotton-growing in Grenada, following on the facts that in past years this crop held an important place among industries of the island, and that the market price of the product is likely to be good for some years to come. Old records show that the annual exports of cotton from Grenada in the eighteenth century have reached 1,000,000 lb. valued probably at about £500,000. In the southern and south-western districts of Grenada there are large tracts of land, including areas of Grand Mal, Point Saline, Caliste, True Blue, Morne Rouge, Grand Anse and Dehar, L'Anse aux Epines, Mount Hardtman, Woodlands, Cialivigny, Wester Hall, Baillie's Bacolet, Requin and Marlmount estates, with an annual rainfall of 35 to 70 inches, which appear in every way suitable for cotton, and which are now unused except for a small amount of sugar-cane. Altogether the total area of unused, cultivatable land can hardly be less than 2,600 acres, and may easily be much more. Repeated trials of cotton have been made on certain of these estates during the last decade, but in almost every case failure has resulted for reasons which have hitherto been obscure, and which are still not clearly understood. Factors which may possibly influence the industry unfavourably, as far as can be judged at present, are the soil, rainfall, labour, unsuitability of the types grown, and the choice of planting season.

Of the late revival of attempts to grow cotton in Grenada, the first record in the possession of the Agricultural Department bears the date 1903. In that year, Mr. L. R. Mitchell ordered 112 lb. of Sea Island cotton seed from the United States. In April 1904, the Imperial Commissioner of Agriculture, Sir Daniel Morris, K.C.M.G., forwarded 442 lb. of Sea Island seed for distribution among the peasantry in Grenada, of which 100 lb. was to be shipped to the dependency of Carriacou. In 1905, the statement is made that there was no Sea Island or Marie Galante cotton in Grenada. In 1906, the first definite reports of departmental activity are available; a considerable amount of attention was paid to the subject by Mr. R. D. Anstead, B.A., then Agricultural Superintendent, and in consequence, four trial plots of Sea Island cotton were laid down, one at the Botanic Gardens, and one each at Wester Hall, in the southern district: Mount Rodney, on the northern coast; and at Point Saline in the extreme south-west. There were several other plots opened in various parts of the island, notably a large area at Bacolet, and preparations were made for handling by Mr. L. R. Mitchell, who imported an oil-engine, two gins and a baling press.

With the exception of the plot at Point Saline, every one of these trials resulted in failure. The 10 acres at Point Saline yielded 4,600 lb. of seed-cotton, giving on ginning 1,200 lb. of lint – an average of 120 lb. per acre. Mr. Thomas Thornton, then

cotton expert to the Imperial Department of Agriculture, reported on this cotton as follows: 'Sample, good medium quality. A little mixed, some parts being short and others weak. The average is of good length, fairly strong, fine and silky. Such a sample indicates that cotton of a good quality can be grown in Grenada.'

In 1910 fresh trials were made in the island. A plot of 7 acres of Sea Island cotton was set out at Point Saline, one of 5 acres at Marlmount in the south-eastern district, one at the Botanic Gardens, and 3 or 4 acres of Marie Galante at True Blue, an estate adjoining Point Saline. Finally the Department secured an area of 4 acres of land near True Blue, and in 1911, trials were made of $\frac{3}{4}$-acre of Sea Island and $\frac{3}{4}$-acre of Marie Galante. Again these trials resulted in failure, with the exception of the Point Saline plot, which yielded well. The 3 acres at True Blue gave 988 ℔. of seed-cotton, which on ginning yielded 290 ℔. of lint. The other plots gave such small amounts that ginning was not worth while. There were several small plots of both types of cotton in the hands of peasants in 1910 and 1911, and all ended in failure.

During the year 1911, the Government erected a small ginnery, fitted with an oil engine, two gins and a hand baling press, which is now under the charge of the local Agricultural Department. Several small lots of both types of cotton were again planted in 1911, and in February and March 1912 the Department ginned about 5 bales of Grenada grown cotton. In 1911 a small area of Sea Island and Marie Galante was planted at Islet Ronde, an islet near Grenada, and 1 bale of each type obtained and ginned at the Government ginnery. The yield from all these plots was poor, and did not repay the cost of cultivation.

Throughout these trials we have been faced with continued failure, and the risk of recommending cotton planting, on even a moderate scale, is too great to be undertaken. The fact remains, however, that large quantities of cotton have been grown in the island, and this success must be capable of repetition if the right conditions are discovered. It appears probable that the old cotton industry of Grenada, coinciding in point of time with the American Revolution and the American Civil War, probably derived its success from the high prices caused by those wars, and there are no records of the extent to which the cultivations suffered from disease, or as to the yield of lint per acre. With artificially high prices, a small yield per acre and poor quality of lint would not make the cultivation unprofitable, and we must guard against assuming too close a parallelism between chances of success in those days and in the present. Grenada's 1,000,000 ℔. of cotton may have represented a yield per acre quite ruinously small at present prices.

The sole immediate cause of the failure of all attempts in the last eight years to re-establish the cotton industry in Grenada appears to have been a bacterial disease of the boll, which attacks both Marie Galante and Sea Island types. A sample of diseased bolls from Morne Rouge was reported on as follows by the Mycologist of the Imperial Department of Agriculture, in January 1912 :—

'The bolls are hard and brown and the lint is discoloured, and the symptoms in general suggest bacterial disease, though I am not quite certain of this. Two of the bolls were infected with a species of Phoma or possibly Diplodia. The spores are unicellular and hyaline and might have belonged to either genus. This fungus was probably saprophytic. The disease is not anthracnose, as the infected spots on the boll caused by this are always bounded by a distinct, slightly raised margin, of a red colour. So far as I am aware, this red border is a constant character of the disease. Moreover, none of the pink fruiting pustules of *Colletotrichum gossypii* were to be seen on the bolls and they are generally present in the centre of the diseased spots when these have attained to any size.'

In 1903, Mr. L. R. Mitchell's Sea Island cotton grew healthily and flowered heavily, and the bolls then 'rusted off'. In October 1907, the *Federalist* reported that the bolls would not open, and dropped off. In that same year Mr. R. D. Anstead reports that the Mount Rodney and Botanic Station plots were destroyed in the same way. The Wester Hall plot in 1907 failed for the same reason. The cotton at Marlmount (Sea Island) in 1910, and that at True Blue (Marie Galante) in 1911 grew well and flowered heavily, then lost enormous numbers of half-developed bolls. Finally, the Department trials in 1911-12, at Morne Rouge with both types, gave every promise of remarkable success until the bolls were formed, and then failed. For days labourers were employed in collecting and burning bolls which had been shed, and in the end trees which had given promise of exceptionally large yields retained a few unhealthy, imperfect bolls.

Grenada cotton has been singularly free, in all the late trials, from serious insect and fungus troubles. In 1907 Mr. Anstead reported a mild outbreak of the cotton worm on $\frac{5}{8}$-acre of cotton at Point Saline; this was easily controlled with Paris green. In that same year, one small plot on the west coast suffered from the cotton aphis, but the attack was not of long duration. No leaf-blister mite was found in all the 1907 trials, and only one or two single trees were affected in 1911. Stainers (*Dysdercus* sp.) have been universally present, in some cases in large numbers. In 1911 the Sea Island cotton ($\frac{1}{2}$-acre) at Morne Rouge was damaged by large numbers of beetles (hard-backs), which cut away the bases of stamens and petals. The Entomologist of the Imperial Department of Agriculture reported on these as follows, in January 1912:—

'The beetles advised in the letter of the Superintendent of Agriculture, Grenada, No. 603 of November 21, are of a species of the family Scarabidae. The larvae probably feed on roots or on organic matter in the soil.

'This provides an interesting record of the flower-eating habits of the adults. The use of Paris green to control the cotton worm would keep this insect in check under most circumstances.'

This insect would, I believe, be very troublesome in the Morne Rouge and True Blue districts if cotton were ever planted there on a large scale. Very mild attacks of angular

leaf spot at True Blue complete the roll of diseases which have been definitely noted. There have been no actual cases of devastation by any disease other than the bacterial boll disease mentioned above. I regard the mere identification of a definite disease as the cause of failure to be a most important step in our efforts at building up afresh the cotton industry. The vague statement that the crop is not suitable for Grenada, or that Grenada is not suitable to the crop, has been continually made but may now be replaced by the more or less confident opinion, that if the bacterial disease can be overcome, or better still, evaded, our cotton cultivation may come back to us. The problem now is, how to evade the boll disease ; and with that settled, there are large chances in favour of a profitable industry being restored, and unused lands being rendered profitable.

The bacterial disease is probably the immediate cause of failure, but is itself induced or intensified by conditions favourable to it. Some of these conditions have already been enumerated above, but a careful analysis and examination of them are needed. It is rare to find a disease persisting for long periods in an area without there being detectable conditions fostering it. The time of planting this crop is not clearly understood in Grenada, and has varied from April until as late as November, in the recent trials. In one or two proved cases recorded by Mr. Anstead in 1907, the crop was lost owing to germination of seed in the boll. These were probably cases where the planting season was exceptionally badly chosen so that the bolls opened in very wet weather, and germination was probably due to the imperfect opening of the bolls consequent on the bacterial attacks.

The following table, showing the average monthy distribution of the rainfall in the cotton districts of Grenada affords a useful index as to the correct time for planting. Carriacou is included for comparison :—

AVERAGE RAINFALL.

	Carriacou, 1903-10.	Richmond Hill, 1903-10.	Point Saline, 1904-10.	Sauteurs, 1904-10.
January	2·84	3·77	1·37	2·86
February	1·80	3·05	0·66	2·37
March	2·21	3·24	0·79	3·63
April	2·39	2·06	0·51	2·49
May	3·38	4·75	2·23	3·63
June	5·83	8·81	4·12	7·47
July	6·84	9·91	5·50	7·79
August	8·53	10·42	4·40	7·95
September	5·58	7·16	2·50	5·65
October	6·76	8·76	4·40	7·60
November	4·24	6·90	3·86	6·29
December	4·86	7·56	3·22	4·90
Total	55·26	76·39	33·56	62·63

Carriacou might safely reap her cotton from January to April, or plant in July and August; as a matter of fact she reaps in January to March. Point Saline has a lengthy reaping season lasting from January to May, on the average. Sauteurs, representing the northern dry districts, can reap from January to April, or plant in July or August. Richmond Hill, whose rainfall is representative of a large southern and south-eastern dry area (Calivigny, Wester Hall, Marlmount, etc.) can reap from January to April and plant from May to September.

Basing suggestions for planting on the rainfall alone, we can erect the following table showing the limits of planting. All other months should be regarded as distinctly dangerous for the purpose:—

TABLE SHOWING SUITABLE MONTHS FOR PLANTING COTTON IN GRENADA.

(Based on rainfall statistics for eight years.)

Month.	Carriacou.	Richmond Hill and neighbourhood.	Point Saline and neighbourhood.	Sauteurs and neighbourhood.
Jany. ...	Too early	Too early	Too early	Too early
Feby. ...	,,	,,	,,	,,
March ...	,,	,,	,,	,,
April ...	,,	,,	Risky	,,
May ...	,,	,,	,,	,,
June ...	Risky	Risky	Fairly safe	Risky
July ...	Safe	Safe	Safe	Safe
Aug. ...	,,	,,	,,	,,
Sept. ...	Risky	Risky	,,	Risky
Oct. ...	,,	Too late	Risky	Too late
Nov. ...	Too late	,,	Too late	,,
Dec. ...	,,	,,	,,	,,

The above table would probably be quite reliable if the failure of the cotton crop were solely due to effects of rain ; but as we only suspect an intimate connexion between the boll disease and the amount of rainfall, the suitable months for planting may perhaps be slightly extended in either direction. In any event, there is a strong suspicion that May and June are too early for planting in Grenada, and July and August the best and safest months.

A point, upon which light is needed, is the actual effect of 'ratooning' on the cotton plant. There is a considerable amount of evidence which bears strongly against the practice, and in some of the West Indian islands the feeling has culminated in fairly strict legislation. A common view among the peasants of Grenada is that plant cotton, that is trees from seed, will always lose the bolls to a greater extent than will the ratoons from trees which have been cut back. In fact I have heard it said that they look for no return from plant cotton ; they make their profit from ratoons. This, it should be remembered, is in connexion with the short-stapled, hardy Marie Galante, whose

hardiness, however, does not prevent it suffering severely from boll disease. In view of the evidence against ratooning, one would naturally hesitate in recommending the practice, but the point is important enough in Grenada to warrant careful trial. The universality of the practice in Carriacou, and the absence of serious outbreaks of boll disease there offer some ground for debate, and the healthy persistence with which native cottons, even in the wet districts of Grenada, will, after being cut back severely, fruit in profusion, tempt one to place some trust in the peasants' view. It is hard to understand why shoots from a mature and healthy stump should not be as vigorous as, or even more vigorous than, those from seedling plants.

The soils upon which the late trials in Grenada have been carried out are fairly varied, as far as their physical characters are concerned. The Point Saline land upon which the crop grew with a fair degree of success was in large part composed of sea sand, and would be classed as a light sandy loam. Sea Island cotton grew luxuriantly here, seed from plants 4 feet high in St. Vincent giving plants which had to be topped back to 6 feet, at Point Saline. At Mount Rodney, the estate upon which Sea Island failed badly, the soil is a fairly heavy black clay with an admixture of limestone, on the whole, much resembling the cotton-growing valleys of Carriacou. Marlmount, Baillie's Bacolet and Wester Hall are rather shallow soils, for the most part composed of heavy volcanic ash opened up to a light texture by fragmentary volcanic products and partly weathered lava fragments. True Blue and Morne Rouge are heavy black volcanic ash soils which set hard on drying and need careful draining. There are no records of trials with this crop on the heavy sour red ferro-aluminous soils of andesitic origin so characteristic of certain parts of Grenada. Without exception, all the trial plots were on land which may for all purposes be regarded as virgin, in the case of Morne Rouge being on newly cleared logwood (Haematoxylon) land, and the others on pasture or scrub land. The southern soils are classed as a whole by Professor Harrison in his *Rocks and Soils of Grenada and Carriacou* as being deficient in potash—a defect which should be kept in mind in future trials. The remarkable effect of ash on the vegetative growth of cotton has been noted in two cases—at Marlmount and Point Saline. Recent trials in the Leeward Islands do not afford much hope that application of potash or any other manure will profitably affect cotton, but we can at least hope in Grenada until definite trials disprove or prove the efficiency of this fertilizer.

Taking the results all round, the cotton has done best on the light sandy soils near the sea, represented by the Point Saline plot; and one is led to the conclusion that texture is the point of maximum importance so far as the soils are concerned, heavy soils possibly having a distinct fostering effect on the boll disease.

The type of cotton known as Marie Galante is by no means pure. Whether the immense diversity of types resulting from a handful of Carriacou Marie Galante seed has arisen through intermixture with other types, or through sporting and mutation, cannot now be even surmised, but it induces hopes

that one or more types suited to conditions in Grenada may be evolved, with the exercise of a little patience. In one field at True Blue in 1911, the following distinct types were recognized in the course of a half hour's visit:—

VARIATION IN MARIE GALANTE.

True Blue field, 1911.

Type 1. Small white flower. Little purple in throat. Filaments white. Anthers and pollen white.
„ 2. Small white flower. Filaments purple. Anthers and pollen white.
„ 3. Large yellow flowers. Anthers and pollen yellow. Filaments yellow.
„ 4. Large yellow flowers. Filaments yellow. Anthers and pollen yellow.
„ 5. Large yellow flowers. Filaments purple. Anthers and pollen white.
„ 6. Large pale-yellow flowers. No purple in throat. Filaments white. Anthers and pollen white.
„ 7. Small yellow flower. No purple in throat. Filaments white. Anthers and pollen white.
„ 8. Flower not known. Leaves almost sessile and much curled. Shoot-axes all shortened.
„ 9. Tree small, erect. Leaf-stalks purple. Flowers whitish. Lint weak but long. (So-called silk cotton.)

It will be noted that these are classified merely on flower characters, habit and the quality of lint not being taken into account. Side by side with manurial and varietal trials should proceed systematic efforts at separating and testing the numerous types now included under the general name 'Marie Galante'.

On the whole, we may sum up by saying that the possibility of a cotton industry in Grenada largely depends upon the extent to which the boll disease can be controlled or evaded. Direct methods of control do not appear feasible, but the problem may be attacked by such indirect methods as attention to the season for planting, trials of a large number of varieties, imported or local, hybridization, selection, and possibly special methods of manuring.

The Department is not at present in a position to undertake extensive trials, and local owners are chary of planting the crop on even a moderate scale. The economic experiments plot at Morne Rouge South, which has kindly been placed at the disposal of the Agricultural Department by the Land Settlement, affords an opportunity for certain trials, and these are accordingly being planned this year. The following series is being laid out in 1912-13:—

A. Ratooning experiments with Marie Galante. $\frac{1}{8}$-acre ratooned, $\frac{1}{8}$-acre seed planted.

B. Trials with sulphate of potash on Marie Galante.
$\frac{1}{16}$-acre ratooned with $1\frac{1}{2}$ cwt. sulphate of potash per acre.
$\frac{1}{16}$ „ „ without „ „ „ „
$\frac{1}{16}$ „ plant cotton with $1\frac{1}{2}$ cwt. „ „ „ „
$\frac{1}{66}$ „ „ „ without „ „

C. Variety experiments.
$\frac{1}{16}$-acre each of several types, among which are Mitafifi, Abassi, Thornton's Hybrid, St. Vincent Sea Island, Selected types of Marie Galante, Grenada 1911 Hybrid (M.G × S.I.).

D. Seasonal trials with Sea Island.
$\frac{1}{32}$-acre planted each month from May to November inclusive.

This series, systematically carried out for a few years, will, it is hoped, yield some information of value to the cotton industry here.

A PLEA FOR CITRUS CULTIVATION IN ST. LUCIA.

BY A. J. BROOKS, F.C.S.

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As far back as the sixteenth century, attention was paid in St. Lucia to the cultivation of such crops as tobacco, ginger and cotton; this was followed later by sugar and coffee, and in more recent years by cacao, limes, coco-nuts, etc.

As in most of the West Indian islands, orange trees and other members of the Citrus family are to be found scattered throughout the various districts, and their fruit when ripe is gathered and sold in the local market or shipped to neighbouring islands; but beyond this no attempt ever appears to have been made in the past, to place this form of cultivation upon a sound or remunerative basis. This was no doubt in a great measure due to the lack of steamship facilities and quick transport, but of late a good deal has been done in this direction and more is expected in the very near future, now that the old argument of not being able to ship the produce no longer holds good.

There are large areas of fertile land in this island admirably suited for citrus fruits; at the same time it must not be concluded that a citrus grove can be successfully established in every locality in which an individual orange or lime tree is found to be thriving.

In treating of this question of citrus cultivation as applied to St. Lucia, it is my desire to deal with practical matters rather than those which are theoretical, with the hope that the following may prove of some assistance and inducement to those who have the opportunity of giving attention to this form of cultivation.

The Citrus family includes such well-known fruits as the orange, lemon, grape fruit, lime, shaddock and citron: the demand for these fruits is increasing annually.

Citrus fruits of a total value of over £100,000 were exported from the British West Indies last year; of this sum Jamaica reaped the major portion, the remainder being shared by Trinidad, Dominica, Tobago and Grenada.

This conclusively proves that good marketable oranges and grape fruit can be successfully grown in these islands, and there is no sound reason why St. Lucia should not share in this remunerative industry.

The Grove.

ALTITUDE. The first question to be considered in establishing a grove is that of altitude. Oranges and grape fruit will thrive well up to an altitude of 2,500 feet. Experience gained in islands similar to St. Lucia tend to show that an altitude from 800 to 1,200 feet is the most suitable.

SITUATION. The situation should be within easy reach of the coast and should afford good facilities for transport; a gentle slope facing south or south-west well sheltered from prevailing winds, should if possible be chosen.

WIND-BELTS. If forest land is chosen care should be taken to leave natural wind-belts; but where this cannot be done, artificial wind-belts of some quick-growing tree must be established. Galba, Pois-doux, Andira, Mango or Kola would answer the purpose. A deep trench should be dug between these wind-belts and the first row of citrus to prevent the roots of the former from spreading into the grove.

SOIL. The question of suitable soil is perhaps even greater than that of altitude.

An excessively dry soil should on no account be used unless irrigation be possible, and heavy soils should also be avoided, as such soils produce inferior fruits with coarse rind, stringy, greenish flesh, tough fibre, numerous seeds and sour taste. The ideal soil is therefore a light sandy loam rich in humus, and of a sufficiently open nature to allow air and water to penetrate freely, and one that will retain sufficient moisture without causing stagnation; such a soil is capable of producing sweet fruits with smooth, thin rinds of bright appearance, bright-coloured flesh and little fibre and few seeds.

RAINFALL. The rainfall should not be below 100 inches per annum, and as much as 250 inches on well-drained forest lands does not appear to have any injurious effects.

Propagation.

Most plants are readily and successfully propagated by seeds, but this method should not be employed if varieties true to name are desired, as citrus plants raised from seed are very liable to variation due to cross-fertilization; for this reason budding is resorted to.

BUDDING. Budding consists in removing an eye or bud with a small portion of bark attached from one plant and uniting it to another. There are many methods adopted in budding, but the one known as T budding has given the best

results when dealing with citrus, and is economical and easily mastered. This method will be described later.

STOCKS. The first step in budding is to secure a supply of good, strong, healthy seedling stocks of sour orange. This can be done by sowing seeds of the common sour orange—which is to be found growing wild in almost every district in this island—in well-prepared beds during October or November; in about eight weeks these should have developed into seedlings large enough to be transplanted. The soil should then be thoroughly watered and the seedlings pulled *straight* up by the hand. The strongest seedlings should then be taken and their tap roots shortened by laying them on a board and cutting with a sharp knife; clippers should not be used as they bruise the roots. This shortening induces the formation of surface-feeding roots, and lessens the danger of injuring the roots when being transplanted. The tops of the young seedlings must also be cut back to about half their length and the leaves clipped. They are now ready to be planted out in nursery beds at 18 inches apart. These beds may be of any size, but in practice, beds 100 feet long by 5 feet wide and slightly raised above the level of the ground to ensure good drainage have proved the most serviceable.

Special care must be taken to see that the seedlings are not planted too deep; they should not be planted any deeper than they orginally stood before transplanting. They should be allowed to grow undisturbed until the following October, when they should be cut back to about 3 inches above the soil. New shoots will be produced readily, and these should be allowed to develop for a few weeks and then the weaker and undesirable shoots should be removed leaving only the stronger to develop. If healthy, this shoot should have grown to about the thickness of a lead pencil by February or March; at this period the sap runs freely and the stock should be ready for budding.

Stocks may be budded when they are but a few months old, and will often continue to thrive as long as they remain undisturbed in the nursery beds; but when removed to other localities and planted out under estate conditions, it invariably happens that this practice ends in disappointment and failure, as the stocks are not sufficiently mature to withstand the general estate conditions. Budding, then, should not be attempted until the stocks are at least twelve months old and have had time to produce a strong root-system.

Numerous varieties of citrus stocks have been used for budding and all have their own particular advantages, but for general cultivation and average conditions the sour orange stock has given by far the best results in these islands.

T BUDDING. Budwood must be obtained from the variety which it is desired to propagate, and this budwood may be angular or round: either kind will do for the purpose, but the round should be used by beginners as it is more easily manipulated, being more mature than the young angular growths. A young, round stem should be selected and removed from the tree chosen to be propagated. All the leaves should be removed, leaving a small piece of each leaf-stalk.

The stock should now be chosen, and all the leaves and prickles removed for about 8 inches from its base. A cross cut with a sharp pocket knife should be made right through to the bark and another cut lengthwise at right angles to it about 1 inch in length. Insert the point of the knife at the point where the two cuts meet and slightly raise the corners of the bark, gently pressing it up on both sides.

From the piece of budwood a well-developed bud should be chosen. This should be removed quickly and with a very sharp, clean knife, taking off as much bark and as little wood as possible. The bud should be about an inch in length, and the wood should not be removed from it as the young bud might be injured in the attempt.

The bud, now held between the finger and the thumb by its edges, must be quickly inserted in the stock. The top of the bud being under the corners of the ⊥ cut is gently pushed up into position. On no account must the cut surface of the bud be touched by the hand, or the sap of the bud will be injured; nor must the blade of the knife be fingered during the process as the moisture from the hand when in contact with the steel of the knife appears to produce an injurious action on the sap.

When the bud has been inserted it should be bound round firmly with raffia or Mahoe bast and then wrapped with budding tape to prevent moisture from gaining access to the bud, or, on the other hand, to lessen the drying of the tissues.

Budding tape may be prepared by dipping some ordinary white ½-inch cotton tape in a mixture composed of 4 oz. beeswax, 2 oz. of resin, ½-oz. of good tallow; the last must be free from salt.

After the bud has been carefully wrapped, the top of the stock should be bent in half; this checks the flow of the sap and induces development of the buds. This practice also enables one to see at a glance what stocks have been operated on.

After ten or twelve days the tape may be unwrapped and the bud examined, and if the latter is found to be growing, the tape may be removed, and when the bud has grown a few inches the stock should be cut back close to the bud. It is very probable that more than one shoot will develop from the bud; if so, the weaker shoots should be pinched off at the earliest opportunity and only the strongest be allowed to develop.

Varieties to be Grown.

Great care and forethought must be given to this question. The varieties of citrus fruits are numerous and all are not suitable for West Indian conditions. A few remarks, therefore, on some of the better-known varieties which have proved a commercial success in these islands may be of some guidance to those wishing to take up this form of cultivation.

In deciding as to what varieties should be grown, the planter must make himself acquainted with the requirements of the particular market for which he intends catering.

If the grove is to be limited to a few acres only, then he should confine himself to the cultivation of but *one* variety, and in choosing this variety he must not be guided by his own personal taste or desires, neither must it be chosen from any sentimental reason as is often the case, but the planter must be guided entirely by what his market demands. Should be decide to restrict himself to one variety, the Washington Navel cannot be too strongly recommended. This is an orange possessing sound qualities, and of good flavour; its special merit, however, lies in the fact of its being seedless, and for this reason it is in increasing demand in the European markets and always fetches fancy prices such as 12*s.* 6*d.* per box of 123, while other oranges of well-known varieties realize but 8*s.* per box of 150.

This orange thrives particularly well in these islands and has yielded good commercial returns. There are to be found, however, in almost all the West Indian islands, local varieties of oranges which have grown from seeds naturally, and which often possess qualities said to be 'superior' to the recently imported varieties; but it is advised, without wishing in any way to depreciate these local varieties, that the planter just establishing a grove will do well to leave these alone and grow only those varieties that are already known in the leading markets, if he wishes his venture to prove profitable.

The following varieties are strongly recommended, as they are well suited to this climate, and being well-known both in England and Canada have given good profitable returns.

ORDINARY ORANGES. Washington Navel, Jaffa, Boone's Early, Parson Brown, Whittaker and King are early varieties, and Valencia Late and Tardiff are excellent late varieties.

GRAPE FRUIT. The Jamaica and Triumph are the most suitable varieties for general cultivation, being vigorous in habit and producing heavy crops.

TANGERINE AND MANDARIN ORANGES. The best variety of tangerine is that known as 'King'; as a good all-round late-fruiting variety it cannot be surpassed. Of the mandarins, 'Satsuma' is a good early bearing variety.

LEMONS. The Genoa and Villa Franca can be thoroughly recommended.

SHADDOCKS. The large variety known as 'Giant' is one of the varieties for general use.

Cultivation and General Treatment.

TRANSPLANTING. This should be done in the rainy season and as early as possible, so as to enable the plant to develop a good root-system before the dry weather sets in.

Citrus plants should be ready for transplanting in from six to nine months after budding, and by that time they should have developed at least two strong shoots. They must not be moved from the nursery beds, however, until there are signs that new growth is being made. All citrus plants are very liable to be killed outright if moved during their dormant period. The head of the plant should be lightly pruned before

moving. The growing tips should be clipped and the leaves cut in halves; this prevents wilting and induces the lateral buds to develop.

The plants should be lifted carefully with a field fork, and all the damaged roots should be cut back. Every care must be taken to protect the roots from the sun. This can be done by having close at hand a bundle of banana trash previously soaked in water to cover the plant while others are being lifted.

If the plants have to travel any great distance the roots should be 'puddled'. This consists in dipping the roots of each plant in a bucket of thin liquid mud, which covers the roots with a thin layer of earth which helps to protect their vitality.

The roots of citrus plants must never be allowed to dry nor be exposed directly to the air or sunshine; such treatment is practically certain to end in the death of the plant. This point cannot be too strongly emphasized, as the practice of allowing labourers to carry bundles of lime plants with their bare roots exposed to the direct rays of the sun throughout the day is far too common a sight.

DISTANCE IN THE GROVE. The distance at which the trees should be set out in the grove depends upon several factors. All citrus plants have a strong tendency to lateral development and this should be encouraged, as the greater this spread the more easily can the fruit be gathered. The exact distance will have to be decided in each particular case, as much depends on the nature of the soil and situation. A distance of 25 feet each way is however a good standard for average conditions, and this allows sixty-nine plants to the acre. The future appearance of the grove will greatly depend on the way in which the plants are set out, and for this reason care should be taken to see that the rows run perfectly parallel and straight. Guava stakes about $4\frac{1}{2}$ feet long and about an inch in diameter, with the top 6 inches painted white, will greatly assist in the lining out, as the white tops can be readily seen. These stakes should be placed in the ground at the required distances.

Circles 2 feet in diameter should be forked around each stake to a depth of $1\frac{1}{2}$ feet, and all the roots and stumps removed. The soil should then be slightly drawn toward the stake so as to raise the centre of the circle above the surrounding level.

In planting, a hole should be made of a sufficient depth to receive the tap root—but not deeper; a certain amount of soil should then be filled in and pressed firmly around it to keep the plant steady. The lateral roots should now be carefully spread out over the mound, and a light covering of soil should be firmly pressed upon them.

Special attention is necessary to see that the trees are not planted too deeply, or much disappointment and trouble will be experienced later; if they are, the plants will be slow in growing and will quickly assume a yellowish, sickly appearance, falling easy victims to disease and scale pests, and often dying back. It is advisable to secure each tree to its stake with a piece of spun yarn at the time of planting out; this helps to

hold the plant firmly in the ground until the root-system has developed, and prevents the wind from loosening the plants at the collar.

GREEN DRESSING CROPS. Should it not be necessary or desirable to cultivate catch crops, then the whole of the intervening spaces between the rows of citrus should be sown with some suitable green dressing crop. There are many plants that may be used for this purpose, such as the horse bean (*Canavalia ensiformis*), woolly pyrol (*Phaseolus Mungo*) and numerous varieties of cowpeas, Crotalaria and Tephrosia. The horse bean has, however, given by far the best practical results locally, both in cacao and lime cultivation, and as seeds of this plant can be readily obtained in the island, it is perhaps the one to be most recommended. Such a crop will prove very beneficial to the grove, keeping the soil cool and moist and adding to it annually large quantities of humus.

The circles around the citrus plants must be maintained free from weeds, and this can be successfully done by keeping them covered with a thick layer of dry grass or leaves. These circles should be enlarged each year by forking around them, but on no account should forking be done within the circle.

Sucker growing from stock of a budded orange plant.

PRUNING. The question of pruning is a somewhat complicated one, most growers having their own special methods, for which they claim special advantages. These methods vary considerably. Some advocate what is known as the *open* method, i.e. the removal of all central branches; while others favour the *natural* method, that is the removal of only dead wood.

The first step in this direction is to see that all suckers are promptly removed, and during the first three years a sharp look-out must be kept for all suckers growing from the stock below the bud. (See illustration.) If these are allowed to develop they will eventually kill out the budded shoot. With regard to the general pruning, Nature will indicate to a certain extent when the foliage becomes too dense by causing the interior branches to dry up. These should be removed, together with any branches growing too near the ground. As citrus plants produce fruit on the exterior, all weak interior growths may be removed with advantage; this will allow a free circulation of light and air.

Manuring.

In considering this question it must be remembered that we are dealing with permanent and not annual crops, therefore no matter how fertile the soil may be when the grove is started, the time will arrive when the application of fertilizers will become essential to the production of saleable fruit.

An average crop of citrus fruits takes from the soil annually from 10 to 11 lb. of phosphoric acid, 36 lb. of nitrogen and 40 lb. of potash per acre. It therefore becomes apparent that this constant draw on the food resources of the soil cannot continue indefinitely without producing exhaustion of the soil. To prevent this, a constant supply of these elements must be kept up by adding them artificially.

On virgin forest soils nitrogen should exist in natural abundance during the first few years, and this would be indicated in a great measure by the growth of the trees. Taking for granted that all other conditions, such as drainage, etc., are satisfactory, a vigorous growth would indicate an abundance of nitrogen, whereas a slow growth would show the opposite.

Should the grove be established on old sugar-cane land, then the plants would be benefited by an application of 1 oz. of sulphate of ammonia, sprinkled evenly over the circle around the plant, about two months after planting. This should then be covered with a thick mulch of decayed vegetable matter, street sweepings or anything that will rot quickly.

The amount of ammonia may be doubled with advantage each year until the trees commence to bear.

When the fruiting stage is reached, nitrogen must be applied cautiously; large quantities of nitrogenous manures, such as dried blood, sulphate of ammonia, nitrate of soda and pen manure would have an injurious effect on the production of the fruit, causing the plants to break out into vigorous growth thus producing coarse and flavourless fruits. At this period, a fertilizer containing 2 parts of nitrogen, 2 parts of potash and 1 part of phosphoric acid will give sound, profitable returns, and such a mixture can readily be obtained from any high-class dealer in fertilizers.

Insect Pests.

Citrus plants are seldom free from scale insects, and unless these are kept under control they are capable of doing injury to the trees. These insects feed on the juices of the plant and often remain unobserved until the trees are seen to assume a sickly, yellowish appearance with numerous leafless twigs.

The most troublesome of these pests are undoubtedly the mussel or purple scale (*Lepidosaphes beckii*), the snow or white scale (*Chionaspis citri*), and the green scale (*Coccus viridis*).

Until quite recently a planter's watchword was 'Watch and Spray', as spraying these pests with a poisonous wash was the only remedy advocated for general application; but science, ever progressing, now teaches us that even scale pests are not without their natural enemies, which under favourable conditions are capable of keeping them in check and thus maintaining the balance of nature.

Since spraying treats friend and foe alike, we are left in doubt as to the advisability of 'changing horses in mid-stream'.*

Among the natural enemies of scale insects are a number of parasitic fungi known, respectively, as the red-headed fungus (*Sphaerostilbe coccophila*); the white-headed fungus (*Ophionectria coccicola*); the black fungus (*Myriangium Duriaei*), and the shield scale fungus (*Cephalosporium lecanii*).

All these fungi are present in this island, and are being introduced gradually into localities where they are not found to exist naturally.

Two methods of control are therefore possible to the citrus grower, one by *natural* control and the other by *artificial* control, i.e. spraying. The virtues of these methods are discussed at some length in the *West Indian Bulletin*, Vol. XI, pp. 14 and 15, and should be read by all interested in this subject.

Experience in St. Lucia and Dominica points to the adoption of *natural* control for general practice, reserving the spraying for badly infected individual trees or patches.

NATURAL CONTROL. This consists in encouraging the development and distribution of the fungi previously mentioned. Small branches, twigs and leaves of citrus trees upon which the scale insects are found to be parasitized should be taken and placed in the heads of trees badly infected with scale and upon which the fungi are not found. These twigs should be securely fixed to the trees, and if dry weather is experienced at the time, spraying daily with clean water will assist development of the fungi and give excellent results. Care must however be taken to see that the spraying apparatus is entirely free from the remains of any injurious washes, or the fungi may be killed.

* Some exception may be taken to these remarks since it has been demonstrated that the kerosene and rosin spray-mixtures can control scale insects without detriment to the beneficial fungi parasites on them. Only in cases where the mixtures is both an insecticide and a fungicide do Mr. Brooke's remarks hold good.—[Ed. *W.I.B.*]

SPRAYING. A spraying machine should form part of every estate outfit. There are numbers of excellent machines on the market and the cost of an efficient machine for general use is trifling.

When it is desirable to spray individual trees, kerosene emulsion or whale oil soap solution will be found very effective. The former is the better of the two but requires more skilful preparation. It is made as follows :—

Dissolve ½-lb. hard soap in 1 gallon of boiling water. Add 2 gallons of kerosene to the hot liquid and immediately churn with a syringe or force pump till the mixture becomes creamy. This is the stock solution. Make up to 33 gallons. Use only rain water, or soft water, i.e. without lime, etc.

Whale oil soap solution is readily prepared by dissolving 1 lb. of whale oil soap in 2 gallons of water. A useful mixture is 'Scalo', orginally prepared by the St. Lucia Department of Agriculture.

GATHERING THE FRUIT.

All kinds of citrus fruits except limes should be cut from the trees with fruit clippers, leaving about ⅛-inch of stem. On no account must they be pulled from the trees. Of the numerous forms of fruit clippers on the market that known as 'Snyder's patent' is probably the best; this clipper holds the fruit by its short stem when cut, and on this account is particularly useful when cutting with one hand from the top of a step-ladder. Clippers with pointed blades should not be used, as the fruit is liable to be punctured.

In gathering fruit from the highest branches a fruit picker should be used ; there are many forms of these on the market, some of which are quite useless for citrus fruits. Fruit pickers with a claw instead of a hook clipper at the end must not be used. A long, narrow bag made of netting or short cotton should be attached to the pole, into which the fruit falls when cut; each fruit should be removed from the picker and placed in a padded basket before the next fruit is gathered.

It should be remembered that gathering the fruit is probably the most important operation in the whole system of citrus culture. A little carelessness at this stage is likely to prevent entirely the hoped-for results from being obtained.

It is often said that citrus fruits should be handled as carefully as eggs : this is not sufficient ; they must be handled with a great deal more care than that. If an egg is handled roughly it breaks and the damage is evident and individual, but should an orange or grape fruit receive the slightest rough handling, such as being *dropped* into the basket or on the ground at the time of gathering, it will, in all probability, suffer from bruising, which unfortunately would not show for several days afterwards. This would lead to decay : and should such a fruit be packed, it would probably mean the loss of the entire box of fruit, besides causing an unfavourable note to be taken of the particular brand in the market.

From the foregoing it will be seen that too much care cannot be taken in the gathering of fruit. Gathering must

only be done on fine, dry days. The fruit should be placed in baskets in which a sack has been put to prevent bruising, and only sound, mature fruits should be gathered.

QUAILING. Citrus fruits must not be packed as soon as gathered. They must be laid out in single layers on drying trays in a cool airy shed to allow the surplus moisture to evaporate from the rinds. The rind will shrink and there will then be less danger of bruising, and the fruit will be in a condition to withstand the pressure of packing without injury.

ORANGES. These should be picked at the first tinge of yellow and when quite full. If gathered earlier they will shrivel and probably arrive at their destination in a green and unsaleable condition.

The rule to be observed in gathering oranges is to give them only sufficient time to colour thoroughly by the time they reach the market. They should be left in the drying trays for about three days previous to packing: this will usually be found sufficient time for proper quailing.

GRAPE FRUIT AND SHADDOCK. These should be allowed to ripen before being gathered; at this stage they should be of a pale straw colour. They will require about the same time for quailing as oranges.

LEMONS. Unlike oranges and grape fruit, lemons require careful curing. The market demands an average-sized fruit ranging from 250 to 300 to the box. Larger sizes are in very little demand and fetch low prices. The fruit should be cut from the trees when about 2 or 2½ inches in diameter, leaving a short piece of stem as in the case of the orange and grape fruit. This, however, should not be longer than ½-inch, otherwise the fruit is liable to be punctured in transit.

The fruits should possess an abundance of juice, thin rind and the characteristic pale straw colour. This can be accomplished by proper curing.

When gathered, the fruit must be washed to remove any dirt. It should then be placed in drying trays for a couple of days and either be wrapped separately, or placed in boxes lined with brown paper and stacked in a darkened portion of the fruit room. At intervals of three weeks, each fruit must be examined and all unsound ones removed. When the fruit has developed the pale straw colour it is ready for the market. In this state lemons can be kept for several months and shipped when desired.

CITRON. This fruit is not in great demand and very few trees are to be found in this island. It is more delicate than any of the other citrus fruits. Commercially it is valuable only for its thick rind, which is 'preserved' or 'candied'. It should be gathered when mature but still green, and should be used in its fresh state.

Grading, Wrapping and Packing.

The standard box for oranges, grape fruit, and lemons is 27 inches by 12½ by 12½ inches, with a centre partition 1 inch in thickness leaving a cubic foot of space on either side. The

object of this partition is to bear the weight of one-half of the fruit when the box is placed on end, thus relieving the bottom layer of fruit from excessive pressure.

Oranges must not be packed with grape fruit; neither must different varieties of the same kind be packed in the same box. Each box should contain fruit of a uniform size; and for this a grading machine should be used. There are many such machines on the market, but a simple grader can be readily made by the average estate carpenter.

GRADING. The standard sizes for oranges are those known as 96, 112, 126, 150, 176, and 200. This represents the number of fruits that can be safely packed in a standard box, those in most demand being 150 and 176.

Grape fruit run from 48 to 80, and lemons 250 to 300 to the box.

Large shaddocks and citrons may be packed in flour barrels similar to those used for green limes, being first wrapped in coarse brown paper.

WRAPPING. When the fruit has been properly quailed and sorted, it should be wrapped in tissue paper. Special wrappers made of the best Manila paper and cut in the standard sizes can be easily obtained. These wrappers should bear the grower's special brand or estate mark, and if uniformity in colour, quality, and size be maintained, and only sound fruit shipped, it will not be long before the brand becomes known and sought for by the wholesale buyers.

PACKING. The fruit should be carefully placed in layers in standard boxes, each layer alternating with the row below; this will give greater elasticity to the whole and reduce the danger of bruising during transit.

When the box is full, the top layer should protrude about $\frac{3}{8}$-inch above the top of the box. The cover should then be placed on the top and gentle pressure exerted upon it to bring it into position. It should then be securely nailed and stencilled at both ends, showing the estate mark or brand together with the number of fruits in each box.

Commercial Returns.

Large areas of Government land suitable for citrus culture can be obtained in this island at £1 per acre payable in five yearly instalments plus the cost of surveying. In addition, every purchaser of such land is allowed budded citrus plants at half the usual cost, namely *3d.* each, and certain other plants free. Labour is fairly plentiful and cheap, men's wages ranging from 1*s.* to 1*s.* 1*d.* per day, 10*d.* for women and 6*d.* for boys. When this is compared with the wages paid in other citrus-growing countries such as Florida, viz. 4*s.* to 6*s.* per day, it will be seen that St. Lucia possesses a distinct natural advantage in this respect.

A small experimental grove of seedless oranges has recently been started in the Soufrière district near the coast, and it is hoped others will follow.

As no virgin forest land has yet been taken up for citrus cultivation in this island it is impossible to give local yields and returns.

Owing to the kindness of Mr. J. Scully, one of the pioneers of citrus cultivation in the forests of Dominica, I am able to give the results of his labours after a period extending over ten years.

The forest lands of Dominica are for all practical purposes identical with those of St. Lucia. The information received from Mr. Scully is therefore very applicable to the conditions existing in this island.

The cost of establishing and maintaining 25 acres of citrus up to seven years old in forest land is about £1,000. This sum includes everything except the original cost of the land.

An acre of citrus trees at this age can be depended upon to produce at least sixty boxes of good marketable fruit. This yield increases yearly until it is often trebled.

An acre of oranges can be thoroughly cultivated at a cost of £3 to £4 per annum : this includes cost of manures.

It has now been proved conclusively that good marketable oranges and grape fruit, capable of obtaining the highest prices in the London and Canadian markets, can be successfully grown in these islands.

Oranges should be shipped to arrive in England between August and December, and to Canada and the United States from September to February. There is however a prohibitive duty of 1c. per lb. on all citrus fruits shipped to the United States from these islands ; and under these circumstances, it seldom pays to ship to this market, as shippers would have to compete with the Florida fruit, which is exempt from duty.

Washington Navel oranges, being seedless, will fetch from 20*s.* to 25*s.* per case of about 120 fruits, and as high as 28*s.* was obtained in London during the last year for such oranges grown on forest lands in Dominica.

Ordinary oranges—not seedless—will fetch from 10*s.* 6*d.* to 12*s.* 6*d.* per case.

Any orange deemed unsuitable for shipment owing to size or colour would find a ready sale locally, and possibly any surplus could be used for extracting the écuelled oil.

About 1lb. of oil can be extracted from 600 fruits, and this is worth at the present time 7*s.* 3*d.* per lb.

The total cost of handling the produce, comprising picking, grading, cleaning, wrapping, cost of boxes, nails and paper, marking, porterage from interior to coast several miles over a mule track only, and including freight to London and Commission, etc., works out at 3*s.* 6*d.* per case.

It will be seen that a very handsome profit remains after deducting the cost of cultivation.

The Present State of the Citrus Industry in St. Lucia.

As previously stated, most of the fruit produced in this island is grown from unnamed varieties, and although excellent fruit in many respects, they are unknown in the European markets, and under these circumstances could not command the higher prices obtainable for known brands.

The bulk of this fruit is grown in the heights of Fond St. Jacques and conveyed by boat to Castries, where quite a good trade is done with steamers calling at this port.

As this fruit is not actually shipped to markets abroad but sold direct to the crews of the steamers, it is impossible to ascertain with any degree of certainty the amount of business done in this way ; but there is no doubt that this particular market is well worth catering for and extending.

Something like 700 plants of special, named varieties of oranges have been distributed from the local Agricultural Experiment Station during the last ten years to various districts in the island. It is to be regretted however, that, judging from enquiries made, only a very few indeed of these plants have survived.

It is known that these unsatisfactory results have had a deterrent influence on the development of this form of cultivation, but the failures experienced are in no way due to the inability of this island to produce citrus, but rather to the lack of knowledge in the handling and general care of the plants. It must be learned that a budded citrus plant is not a cane cutting, and the sooner this fact is grasped the better it will be for the whole Citrus family.

Oranges first appear as an article of export from St. Lucia in 1902, when fruits to the value of 10*s.* were shipped to Barbados.

During the following two years small shipments of a total value of £1 15*s.* were made to the United Kingdom and Barbados.

No further shipments were made until 1907 ; since then oranges to the total value of £107 7*s.* 2*d.* have been shipped. Some of this fruit was sent to St. Vincent, Bermuda, St. Martins, and St. Kitts ; the bulk however was exported to Barbados and the United Kingdom.

In this connexion it is interesting to note that attention has been paid to Barbados as a possible market for this class of fruit, and from the following table it will be seen that this trade is developing :—

VALUE OF ORANGES EXPORTED FROM ST. LUCIA TO BARBADOS.

Year.	Quantity, pkgs.	Value.
1907	4	£ 3 10 0
1908	28	13 11 0
1909	42	28 6 2
1910	64	24 7 0
1911	63	28 18 0

Every possible effort should be made to secure Barbados as a market for our local oranges and grape fruit. Although this market may not offer such fancy prices as the London or Canadian markets, it has several advantages such as shorter distance, thus reducing freight; and our oranges should find a ready sale there throughout the season instead of at certain periods. The market also would not be so particular as to the question of grading and varieties as the home markets.

This object could possibly be attained by the formation of a small company in Castries which could receive the fruit as it arrived from the country districts.

The fruit should be kept in a suitable store for a couple of days after being received, to allow any bruised fruits to become manifest. They should then be carefully cleaned, graded and wrapped and finally packed in attractive cases. These cases should then be consigned to an agent appointed by the company living in Barbados, whose duty it would be to receive the fruit upon arrival in that island and report on its condition, and to keep the company posted with the requirements of the market. In this way I believe that quite a useful intercolonial fruit trade could be developed.

In conclusion I would add that citrus cultivation is particularly suited for those having a limited capital and small income, as no large outlay is required for the erection of works, such as is necessary for sugar, cacao, or lime cultivation. All that is required in this way is a suitable building in which to quail and pack the fruit when it has been gathered.

There are no messy operations in the handling of the produce as in the case of the sweating of cacao, or the concentration of lime juice, and *intensive* rather than *extensive* cultivation can be followed. Thus the cost of management is materially reduced.

THE TUBERCULIN TEST IN THE WEST INDIES.

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Tuberculosis is a disease which has engaged attention in the West Indies during the past year or so, to a much greater extent than formerly. In some of the islands the amount of tuberculosis in cattle which has come under notice, clinically, and microscopically, has been sufficient to draw attention to its importance as an economic factor. It was in consequence decided to undertake a series of tests by means of tuberculin, and the object of the present article is to set forth the methods employed and the results obtained. The tests were made at about twenty different estates on average animals kept under ordinary estate conditions. It is necessary to explain that the cattle on the majority of estates are divided into two flocks, the breeding flock and the working oxen. The primary idea was to test the bulls and cows, as these animals by propagating their species with a predisposition to the disease, would be the more dangerous factors in disease production. Young animals and working oxen, however, were tested as well.

The cattle are confined in pens which vary in size according to locality and number of animals. Advantage is taken of old buildings in the construction of the pens. As a rule they are walled or fenced and one part, generally about one-third of the area, is roofed as a protection against rain and sun. Feeding troughs are placed against the walls for the feed of cane-tops and molasses, but whole cane-tops and—in the dry weather when grazing is scarce,—bush are thrown on to the floor of the pen. This with the cane trash and the evacuations of the animals constitutes a very valuable manure and is allowed to accumulate in the pen to the height of 3 or 4 feet. It will be realized, however, that from a sanitary standpoint the system leaves a good deal to be desired, in view of the fact that all animals are loose in the pen and that they eat and rest-sleep on what is practically their own dung.

There were many difficulties in the way of carrying out the tuberculin test in question. It is necessary to inject the dose of tuberculin, at the same time taking the animal's temperature, and then to take the temperature again at the ninth, twelfth, fifteenth and eighteenth hours after injection. The writer found it most convenient for all concerned to inject the dose of tuberculin at 9 p.m. and to take temperatures the following day at 6, 9 and 12 a.m. and at 3 p.m., in this way handling the animals only once at night.

The method of handling animals was as follows:—A rope with a noose or slip-knot was passed over the animal's horns and the head drawn up to a stout post in the pen, one of the roof supports answering the purpose in the absence of anything else.. A leg rope was then placed round the hind legs above

the hocks, and the free end passed from behind forward over the rope already in position and passed back again underneath between the legs and pulled taut by one or two men behind. It sometimes happened that an animal in struggling threw itself to the ground, and it was then kept down while the injection was being made. This method was found to be sufficient for almost any animal, but considerable difficulty was experienced in the case of several, pure-bred Zebu animals, chiefly bulls, and in some few cases they were so obviously fatigued, as evidenced by the laboured breathing and profuse perspiration, that the test was not at that time applied. Too much reliance could not be placed on the cattle-minders and other helpers, whose assistance and attention was not always available at the critical moment. The writer tried at first to keep the animals tied by their head-ropes during the time the test lasted, but though this made handling much quicker and easier, it was found expedient to give it up, as the young animals did not eat, and fretted considerably. Each animal therefore had to be caught and roped each time, both before injection and at the subsequent taking of temperature, and this very often meant a considerable length of time before all the animals were caught and dealt with.

The tuberculin used in these tests was obtained from the Royal Veterinary College, London, (Sir John McFadyean, Dean) and the directions enclosed, were followed as far as possible. The tuberculin was kept in the ice-chest and was in perfect condition at the conclusion of the tests, some three months after arrival.

The full dose (3 c.c.) was injected in most cases. Young animals below two years old received varying doses of about 2 c.c. In two cases the dose was increased to 4 c.c., both these being bulls of more than ordinary size.

The injection was performed in the great majority of cases in front of the shoulder, but if from any cause the shoulder was unsuitable (e.g., through the presence of shoulder abscesses), the site chosen was on the chest wall behind the elbow.

McFadyean considers a rise from the normal (101°-102° F.) to 104° F. or more, a positive reaction, and a small rise to under 103° F. a negative reaction, whilst those intermediate ones, between 103° F. and 104° F. are doubtful. This is the authority, with one or two exceptions, on which diagnosis was based in the present series of tests.

Eber (International Veterinary Congress, Budapest, 1905) says that for young cattle, under 104° F. before testing, all rises over 104° F. are positive reactions, if the difference between the highest temperature before injection and the highest after injection is 0·9° F. or more. Also, in dealing with cattle of more than six months old, he considers all rises between 103·1° F. and 104° F. positive, if the rise is 1·8° F. In one or two cases, diagnosis was based on this principle, when the history of the case and clinical appearance of the animal appeared to justify it.

An analysis of the results reveals the following facts :—

Class of animal.	Number.	No. affected.	No. doubtful.	No. non-affected.	Percentage affected.
Bulls	24	6	2	18	25
Working oxen ...	42	17	—	25	40·5
Steers	10	2	—	8	20
Cows	67	9	—	58	13·4
Heifers	17	3	—	14	17·6
Totals ...	160	37	2	123	Average percentage, 23·1

The total number affected was 37, and the average percentage works out at 23·1 —nearly one-quarter of those tested.

It is an interesting point that of twenty-five suspected animals, that is to say, animals which appeared to be clinically affected, seventeen were reactors, a percentage of 68. A more interesting point, however, and one which has much more significance is that of 135 which were not suspected, twenty-three were found by the test to be affected, a percentage of 17.

The injection was only attended by ill effects in one case—an old ox—in which a large swelling developed below the point of injection. This was incised and the animal made an uneventful recovery. The swelling contained a dropsical fluid which invaded the subcutaneous tissues. This animal did not react to the test.

A young bull fifteen months old was evidently distressed the day following the injection and the temperature rose to 105° F. and remained at this point for two days. The reaction was regarded as inconclusive and the test was made again ten weeks later, when he reacted. Amongst the reactors it was found that the highest temperature occurred as follows : At the twelfth hour after injection 25·5 per cent. ; fifteenth, 40 per cent. ; eighteenth, 32·5 per cent. ; and after then in 5 per cent. of the cases. The average point, therefore is presumably between the fifteenth and eighteenth hours, with the majority nearer to the fifteenth. This same result was experienced with regard to the non-reactors, the highest point, not of course sufficient to be considered a reaction, being found to be between the fifteenth and eighteenth hours after injection of the tuberculin.

The most common manifestation of the disease visible to the naked eye is the presence of the multiple cold abscesses, which are found in the region of the shoulder, where they are

supposed to have been started by injury from the bow of the yoke, and at times are seen on the face and on the quarters. They may be observed as a mass of huge size covering the entire neck and shoulder, or, as many small swellings, each not bigger than a walnut, situated at more or less regular intervals. These small swellings are lymphatic glands affected with tuberculosis and the larger masses are the result of coalescence of the smaller ones. In character they are of the nature of cold abscesses and are not painful: they are more or less hard to the touch and when cut into are found to contain a caseating mass of pus which is thick and creamy in consistency and usually greenish-yellow in colour. They offer considerable resistance to the knife when an incision is made. On several occasions the presence of tubercle bacilli was demonstrated in these abscesses. Glandular swellings are a common physical feature of tuberculosis but the writer has never before seen masses of such huge proportions. Coming to the tuberculin test for proof, it was found that of nine animals having these abscesses, which were tested, eight reacted, whilst it appears reasonable to put down the error in the ninth case to deficiency in the test rather than error of diagnosis.

Another glandular swelling commonly found in reactors, and in apparently healthy animals also, is that of the precrural lymphatic gland, situated in the flank, immediately in front of the stifle-joint. The swelling may be seen on one or both sides. In health this gland is less than the size of a man's thumb, but when diseased may reach 9 or 10 inches. One example in an aged cow which was tested recently and which reacted, was between 10 and 11 inches long and nearly 4 inches in breadth. These affected glands are congested and enlarged but only very rarely were they found to contain pus.

Age was not found to exert much influence in the present series of tests, and no definite results as to the susceptibility or resistance of the different breeds were obtained. The figures show that males are more affected than females, but the numbers are too small to be conclusive. Usually the sexes are equally affected. Climate has a great influence on the disease. It was once thought to be confined to temperate conditions, but this is not so. The disease appears to be more common now in the West Indies than formerly, but this is probably due merely to an increased knowledge of it. The present occasion is, however, so far as the writer is aware, the first that tests for tuberculosis in cattle have been carried out, even to this limited extent, in the British West Indies, with some possible exceptions on Government Stock Farms and in these cases no results appear to have been published.

The conditions under which animals are kept, fed, and worked are points which may influence the disease, while previous disease and the effects of prolonged droughts such as are unfortunately experienced in the West Indies, weaken the natural resistance and render an animal more liable to tuberculosis.

It has been possible in some few cases to investigate the accuracy of the test. One reactor died soon after the test, and

was buried without an autopsy being made. Two other animals, a working ox and a cow which had both reacted were losing condition and were shot. These both shewed tuberculous lesions. A young bull which had reacted and which at the time was in excellent condition fell off considerably in a few months. He was slaughtered and it was found possible to confirm the results of the test. Thus of the thirty-seven which this test revealed, four are dead and in no case is there any reason to suspect anything but tuberculosis as the cause of death.

[Pages 293 to 385, issued September 22, 1913.]